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Task IV: Classical Graph Neural Network (GNN) Part

For Task IV, you will use ParticleNet's data for Quark/Gluon jet classification available here with its corresponding description.

- Choose 2 Graph-based architectures of your choice to classify jets as being quarks or gluons. Provide a description on what considerations you have taken to project this point-cloud dataset to a set of interconnected nodes and edges.
- Discuss the resulting performance of the 2 chosen architectures.

Downloading the Dataset

In [1]:
```
!wget https://zenodo.org/record/3164691/files/QG_jets.npz?download=1 -O QG_jets.npz
```

```
--2021-03-19 13:56:00--  https://zenodo.org/record/3164691/files/QG_jets.npz?download=1
Resolving zenodo.org (zenodo.org)... 137.138.76.77
Connecting to zenodo.org (zenodo.org)|137.138.76.77|:443... connected.
HTTP request sent, awaiting response... 200 OK
Length: 106689379 (102M) [application/octet-stream]
Saving to: 'QG_jets.npz'

QG_jets.npz         100%[===================>] 101.75M  22.1MB/s    in 5.0s

2021-03-19 13:56:06 (20.3 MB/s) - 'QG_jets.npz' saved [106689379/106689379]
```

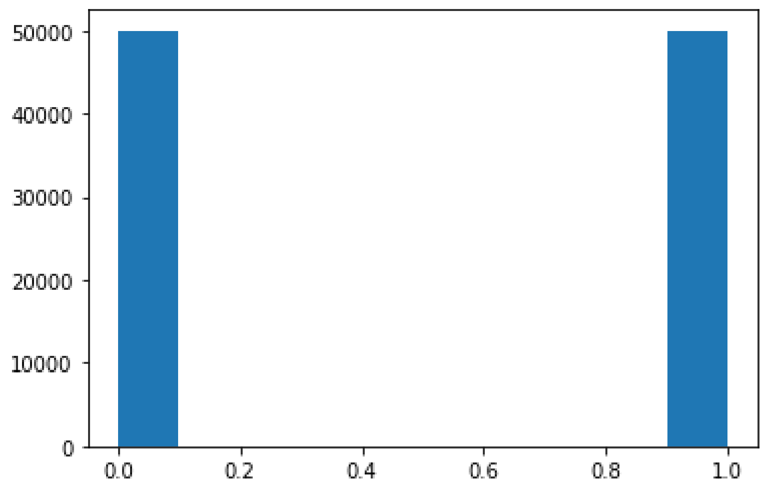
In [2]:
```
import numpy as np

%matplotlib inline
import matplotlib.pyplot as plt
```

In [3]:
```
with np.load('./QG_jets.npz') as data:
  X = data['X']
  y_train = data['y']
print(X.shape)
print(y_train.shape)
```

```
(100000, 139, 4)
(100000,)
```

In [4]:
```
plt.hist(y_train)
plt.show()
```



In [5]:
```
x_train = []
for i in X:
  x_train.append(i[0])
x_train = np.array(x_train)
print(x_train.shape)
```

```
(100000, 4)
```

In [6]:
```
!pip install dgl-cu101
import dgl
import torch
import networkx as nx
```

```
Requirement already satisfied: dgl-cu101 in /usr/local/lib/python3.7/dist-packages (0.6.0.post1)
Requirement already satisfied: requests>=2.19.0 in /usr/local/lib/python3.7/dist-packages (from dgl-cu101) (2.23.0)
Requirement already satisfied: scipy>=1.1.0 in /usr/local/lib/python3.7/dist-packages (from dgl-cu101) (1.4.1)
Requirement already satisfied: numpy>=1.14.0 in /usr/local/lib/python3.7/dist-packages (from dgl-cu101) (1.19.5)
Requirement already satisfied: networkx>=2.1 in /usr/local/lib/python3.7/dist-packages (from dgl-cu101) (2.5)
Requirement already satisfied: idna<3,>=2.5 in /usr/local/lib/python3.7/dist-packages (from requests>=2.19.0->dgl-cu101) (2.10)
Requirement already satisfied: urllib3!=1.25.0,!=1.25.1,<1.26,>=1.21.1 in /usr/local/lib/python3.7/dist-packages (from requests>=2.19.0->dgl-cu101) (1.24.3)
Requirement already satisfied: certifi>=2017.4.17 in /usr/local/lib/python3.7/dist-packages (from requests>=2.19.0->dgl-cu101) (2020.12.5)
Requirement already satisfied: chardet<4,>=3.0.2 in /usr/local/lib/python3.7/dist-packages (from requests>=2.19.0->dgl-cu101) (3.0.4)
Requirement already satisfied: decorator>=4.3.0 in /usr/local/lib/python3.7/dist-packages (from networkx>=2.1->dgl-cu101) (4.4.2)
Using backend: pytorch
```

Approach

I am choosing the following two graph-based architectures:

1. Node Classification

2. Graph Classification

Node Classification

In this approach, I will encode the data as nodes of a graph and then train a GNN to learn to classify these nodes. In this way we can build a classifier which classifies quarks from gluons.

Graph Classification

In this approach, I will encode each training sample as a graph, resulting in a training data of different graphs. I will then train a GNN to learn to classify different graphs. In this way too we can build a classifier which classifies quarks from gluons.

Node Classification

Let us begin by preparing the dataset. We will use a small subset of the training data for demonstration.

In [47]:
```
x_train_small = x_train[:2000].astype(np.float32)
y_train_small = y_train[:2000]
class NodeClassificationDataset(dgl.data.DGLDataset):
  """A Class to process and convert the numpy training data into Graphs so that it can be used in GNNs"""
  def __init__(self):
    super().__init__(name='node_classification')
    self.num_classes = 2

  def process(self):
    node_features = torch.from_numpy(x_train_small)
    node_labels = torch.from_numpy(y_train_small).long()

    self.graph = dgl.from_networkx(nx.generators.fast_gnp_random_graph(x_train_small.shape[0], 0.008, seed=1337))
    self.graph.ndata['feat'] = node_features
    self.graph.ndata['label'] = node_labels
    # self.graph.ndata['weight'] = None

    n_nodes = x_train_small.shape[0]
    n_train = int(n_nodes * 0.8)
    n_val = int(n_nodes * 0.1)
    train_mask = torch.zeros(n_nodes, dtype=torch.bool)
    val_mask = torch.zeros(n_nodes, dtype=torch.bool)
    test_mask = torch.zeros(n_nodes, dtype=torch.bool)
    train_mask[:n_train] = True
    val_mask[n_train:n_train+n_val] = True
    test_mask[n_train+n_val:] = True
    self.graph.ndata['train_mask'] = train_mask
    self.graph.ndata['val_mask'] = val_mask
    self.graph.ndata['test_mask'] = test_mask

  def __getitem__(self, idx):
    return self.graph

  def __len__(self):
    return 1

node_classif_dataset = NodeClassificationDataset()
node_classif_graph = node_classif_dataset[0]

print(node_classif_graph)
```

```
Graph(num_nodes=2000, num_edges=31988,
      ndata_schemes={'feat': Scheme(shape=(4,), dtype=torch.float32), 'label': Scheme(shape=(), dtype=torch.int64), 'train_mask': Scheme(shap
e=(), dtype=torch.bool), 'val_mask': Scheme(shape=(), dtype=torch.bool), 'test_mask': Scheme(shape=(), dtype=torch.bool)}
      edata_schemes={})
```

Defining the Model

In [48]:
```
from dgl.nn import GraphConv

class NodeClassificationModel(torch.nn.Module):
  """A Model Class having the methods to implement and forward pass a GNN."""
  def __init__(self, in_feats, num_classes):
    super(NodeClassificationModel, self).__init__()
    self.conv1 = GraphConv(in_feats, 16)
    self.conv2 = GraphConv(16, 32)
    self.conv3 = GraphConv(32, 64)
    self.conv4 = GraphConv(64, num_classes)

  def forward(self, g, in_feat):
    h = self.conv1(g, in_feat)
    h = torch.nn.functional.elu(h)
    h = self.conv2(g, h)
    h = torch.nn.functional.relu(h)
    h = self.conv3(g, h)
    h = torch.nn.functional.relu(h)
    h = self.conv4(g, h)
    return h

node_classif_model = NodeClassificationModel(node_classif_graph.ndata['feat'].shape[1], node_classif_dataset.num_classes)
```

Defining the Training Loop

In [49]:
```
def train(g, model, num_epochs):
  """The function implementing the main train loop."""
```

```python
  losses = []
  accs = {'train':[], 'val': [], 'test': []}
  optimizer = torch.optim.Adam(model.parameters(), lr=1*1e-5, betas=(0.6, 0.7))
  best_val_acc = 0.0
  best_test_acc = 0.0

  features = g.ndata['feat']
  labels = g.ndata['label']
  train_mask = g.ndata['train_mask']
  val_mask = g.ndata['val_mask']
  test_mask = g.ndata['test_mask']

  for e in range(num_epochs):
    model.train()
    logits = model(g, features)
    preds = logits.argmax(1)

    loss = torch.nn.functional.cross_entropy(logits[train_mask], labels[train_mask])

    train_acc = (preds[train_mask] == labels[train_mask]).float().mean()
    val_acc = (preds[val_mask] == labels[val_mask]).float().mean()
    test_acc = (preds[test_mask] == labels[test_mask]).float().mean()
    losses.append(loss)
    accs['train'].append(train_acc)
    accs['val'].append(val_acc)
    accs['test'].append(test_acc)

    if best_val_acc < val_acc:
      best_val_acc = val_acc
      best_test_acc = test_acc

    with torch.no_grad():
      optimizer.zero_grad()
      loss.backward()
      optimizer.step()

    if e % 5 == 0:
      print('In epoch {}, loss: {:.8f}, val acc: {:.8f} (best {:.8f}), test acc: {:.8f} (best {:.8f})'.format(
            e, loss, val_acc, best_val_acc, test_acc, best_test_acc))

  return losses, accs
```

In [50]:

```python
node_classif_graph = node_classif_graph.to('cuda')
node_classif_model = node_classif_model.to('cuda')
node_classif_losses, node_classif_accs = train(node_classif_graph, node_classif_model, 5000)
```

```
In epoch 0, loss: 7.58675766, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 5, loss: 7.52613258, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 10, loss: 7.46548605, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 15, loss: 7.40483522, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 20, loss: 7.34418201, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 25, loss: 7.28349257, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 30, loss: 7.22277641, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 35, loss: 7.16203165, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 40, loss: 7.10127878, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 45, loss: 7.04049969, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 50, loss: 6.97972059, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 55, loss: 6.91894579, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 60, loss: 6.85817337, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 65, loss: 6.79738712, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 70, loss: 6.73660135, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 75, loss: 6.67581320, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 80, loss: 6.61501265, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 85, loss: 6.55420113, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 90, loss: 6.49337482, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 95, loss: 6.43254089, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 100, loss: 6.37171125, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 105, loss: 6.31088257, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 110, loss: 6.25004530, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 115, loss: 6.18919373, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 120, loss: 6.12830448, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 125, loss: 6.06740475, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 130, loss: 6.00650215, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 135, loss: 5.94559526, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 140, loss: 5.88468790, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 145, loss: 5.82376814, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 150, loss: 5.76285076, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 155, loss: 5.70193863, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 160, loss: 5.64101458, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 165, loss: 5.58008289, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 170, loss: 5.51917171, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 175, loss: 5.45826530, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 180, loss: 5.39735985, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 185, loss: 5.33644342, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 190, loss: 5.27552843, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 195, loss: 5.21461868, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 200, loss: 5.15370750, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 205, loss: 5.09279680, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 210, loss: 5.03188276, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 215, loss: 4.97097397, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 220, loss: 4.91007376, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 225, loss: 4.84918690, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 230, loss: 4.78831148, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 235, loss: 4.72745705, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 240, loss: 4.66661358, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 245, loss: 4.60578108, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 250, loss: 4.54496861, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 255, loss: 4.48415995, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 260, loss: 4.42335796, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 265, loss: 4.36256027, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
```

```
In epoch 270, loss: 4.30177927, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 275, loss: 4.24101162, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 280, loss: 4.18026304, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 285, loss: 4.11953497, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 290, loss: 4.05883217, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 295, loss: 3.99813819, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 300, loss: 3.93746114, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 305, loss: 3.87680888, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 310, loss: 3.81618595, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 315, loss: 3.75558925, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 320, loss: 3.69501686, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 325, loss: 3.63446736, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 330, loss: 3.57394814, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 335, loss: 3.51345515, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 340, loss: 3.45300221, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 345, loss: 3.39258385, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 350, loss: 3.33219910, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 355, loss: 3.27186465, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 360, loss: 3.21156645, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 365, loss: 3.15131855, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 370, loss: 3.09112120, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 375, loss: 3.03098631, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 380, loss: 2.97090626, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 385, loss: 2.91088462, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 390, loss: 2.85092783, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 395, loss: 2.79104614, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 400, loss: 2.73125172, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 405, loss: 2.67154765, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 410, loss: 2.61193562, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 415, loss: 2.55242968, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 420, loss: 2.49305105, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 425, loss: 2.43380952, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 430, loss: 2.37470722, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 435, loss: 2.31575871, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 440, loss: 2.25698709, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 445, loss: 2.19841099, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 450, loss: 2.14003897, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 455, loss: 2.08189273, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 460, loss: 2.02402067, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 465, loss: 1.96644115, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 470, loss: 1.90917528, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 475, loss: 1.85225689, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 480, loss: 1.79574692, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 485, loss: 1.73967946, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 490, loss: 1.68409526, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 495, loss: 1.62905431, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 500, loss: 1.57459867, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 505, loss: 1.52080321, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 510, loss: 1.46774113, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 515, loss: 1.41549015, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 520, loss: 1.36413789, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 525, loss: 1.31376791, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 530, loss: 1.26448059, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 535, loss: 1.21638441, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 540, loss: 1.16958606, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 545, loss: 1.12418795, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 550, loss: 1.08034098, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 555, loss: 1.03815353, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 560, loss: 0.99777764, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 565, loss: 0.95935583, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 570, loss: 0.92302316, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 575, loss: 0.88893038, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 580, loss: 0.85723078, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 585, loss: 0.82805395, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 590, loss: 0.80154037, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 595, loss: 0.77782011, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 600, loss: 0.75700998, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 605, loss: 0.73919344, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 610, loss: 0.72445619, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 615, loss: 0.71282732, val acc: 0.47999999 (best 0.47999999), test acc: 0.52499998 (best 0.52499998)
In epoch 620, loss: 0.70430928, val acc: 0.47000000 (best 0.47999999), test acc: 0.51499999 (best 0.52499998)
In epoch 625, loss: 0.69885343, val acc: 0.47000000 (best 0.47999999), test acc: 0.50500000 (best 0.52499998)
In epoch 630, loss: 0.69627380, val acc: 0.48999998 (best 0.50000000), test acc: 0.44000000 (best 0.47499999)
In epoch 635, loss: 0.69583642, val acc: 0.51999998 (best 0.51999998), test acc: 0.44499999 (best 0.44499999)
In epoch 640, loss: 0.69578665, val acc: 0.51999998 (best 0.52999997), test acc: 0.44000000 (best 0.42999998)
In epoch 645, loss: 0.69572657, val acc: 0.52499998 (best 0.52999997), test acc: 0.44000000 (best 0.42999998)
In epoch 650, loss: 0.69565004, val acc: 0.52499998 (best 0.52999997), test acc: 0.44000000 (best 0.42999998)
In epoch 655, loss: 0.69556272, val acc: 0.51999998 (best 0.52999997), test acc: 0.44499999 (best 0.42999998)
In epoch 660, loss: 0.69547051, val acc: 0.52999997 (best 0.52999997), test acc: 0.44000000 (best 0.42999998)
In epoch 665, loss: 0.69537741, val acc: 0.51999998 (best 0.52999997), test acc: 0.44499999 (best 0.42999998)
In epoch 670, loss: 0.69529325, val acc: 0.51999998 (best 0.52999997), test acc: 0.44499999 (best 0.42999998)
In epoch 675, loss: 0.69521403, val acc: 0.51999998 (best 0.52999997), test acc: 0.44499999 (best 0.42999998)
In epoch 680, loss: 0.69513440, val acc: 0.51999998 (best 0.52999997), test acc: 0.43500000 (best 0.42999998)
In epoch 685, loss: 0.69506544, val acc: 0.51999998 (best 0.52999997), test acc: 0.43500000 (best 0.42999998)
In epoch 690, loss: 0.69499338, val acc: 0.51999998 (best 0.52999997), test acc: 0.44000000 (best 0.42999998)
In epoch 695, loss: 0.69492060, val acc: 0.51999998 (best 0.52999997), test acc: 0.43500000 (best 0.42999998)
In epoch 700, loss: 0.69484758, val acc: 0.51999998 (best 0.52999997), test acc: 0.43500000 (best 0.42999998)
In epoch 705, loss: 0.69477630, val acc: 0.51999998 (best 0.52999997), test acc: 0.44000000 (best 0.42999998)
In epoch 710, loss: 0.69470459, val acc: 0.51999998 (best 0.52999997), test acc: 0.44000000 (best 0.42999998)
In epoch 715, loss: 0.69463438, val acc: 0.52999997 (best 0.52999997), test acc: 0.44000000 (best 0.42999998)
In epoch 720, loss: 0.69456369, val acc: 0.51999998 (best 0.52999997), test acc: 0.44499999 (best 0.42999998)
In epoch 725, loss: 0.69449270, val acc: 0.52499998 (best 0.52999997), test acc: 0.44000000 (best 0.42999998)
In epoch 730, loss: 0.69442004, val acc: 0.51999998 (best 0.52999997), test acc: 0.44999999 (best 0.42999998)
In epoch 735, loss: 0.69434690, val acc: 0.51999998 (best 0.52999997), test acc: 0.44499999 (best 0.42999998)
In epoch 740, loss: 0.69427222, val acc: 0.50999999 (best 0.52999997), test acc: 0.44499999 (best 0.42999998)
In epoch 745, loss: 0.69419807, val acc: 0.50999999 (best 0.52999997), test acc: 0.44999999 (best 0.42999998)
In epoch 750, loss: 0.69412529, val acc: 0.50999999 (best 0.52999997), test acc: 0.45499998 (best 0.42999998)
In epoch 755, loss: 0.69405639, val acc: 0.50500000 (best 0.52999997), test acc: 0.44999999 (best 0.42999998)
In epoch 760, loss: 0.69398397, val acc: 0.51999998 (best 0.52999997), test acc: 0.44999999 (best 0.42999998)
In epoch 765, loss: 0.69391328, val acc: 0.51999998 (best 0.52999997), test acc: 0.44499999 (best 0.42999998)
In epoch 770, loss: 0.69384468, val acc: 0.50999999 (best 0.52999997), test acc: 0.44499999 (best 0.42999998)
In epoch 775, loss: 0.69377786, val acc: 0.51999998 (best 0.52999997), test acc: 0.44499999 (best 0.42999998)
In epoch 780, loss: 0.69371146, val acc: 0.50999999 (best 0.52999997), test acc: 0.44000000 (best 0.42999998)
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In epoch 785, loss: 0.69364572, val acc: 0.51999998 (best 0.52999997), test acc: 0.44999999 (best 0.42999998)
In epoch 790, loss: 0.69357771, val acc: 0.51499999 (best 0.52999997), test acc: 0.44999999 (best 0.42999998)
In epoch 795, loss: 0.69350785, val acc: 0.51999998 (best 0.52999997), test acc: 0.45499998 (best 0.42999998)
In epoch 800, loss: 0.69344223, val acc: 0.52999997 (best 0.53499997), test acc: 0.45999998 (best 0.45999998)
In epoch 805, loss: 0.69337636, val acc: 0.52999997 (best 0.53999996), test acc: 0.45499998 (best 0.45999998)
In epoch 810, loss: 0.69331336, val acc: 0.53499997 (best 0.53999996), test acc: 0.44999999 (best 0.45999998)
In epoch 815, loss: 0.69325083, val acc: 0.52999997 (best 0.53999996), test acc: 0.44999999 (best 0.45999998)
In epoch 820, loss: 0.69319117, val acc: 0.52999997 (best 0.53999996), test acc: 0.44999999 (best 0.45999998)
In epoch 825, loss: 0.69313407, val acc: 0.53499997 (best 0.53999996), test acc: 0.45499998 (best 0.45999998)
In epoch 830, loss: 0.69308221, val acc: 0.52999997 (best 0.53999996), test acc: 0.46500000 (best 0.45999998)
In epoch 835, loss: 0.69303054, val acc: 0.53499997 (best 0.53999996), test acc: 0.46500000 (best 0.45999998)
In epoch 840, loss: 0.69297707, val acc: 0.52999997 (best 0.53999996), test acc: 0.45999998 (best 0.45999998)
In epoch 845, loss: 0.69291991, val acc: 0.52999997 (best 0.53999996), test acc: 0.46500000 (best 0.45999998)
In epoch 850, loss: 0.69286638, val acc: 0.52999997 (best 0.53999996), test acc: 0.46500000 (best 0.45999998)
In epoch 855, loss: 0.69281232, val acc: 0.52999997 (best 0.53999996), test acc: 0.46500000 (best 0.45999998)
In epoch 860, loss: 0.69275606, val acc: 0.52499998 (best 0.53999996), test acc: 0.47000000 (best 0.45999998)
In epoch 865, loss: 0.69270307, val acc: 0.51999998 (best 0.53999996), test acc: 0.47000000 (best 0.45999998)
In epoch 870, loss: 0.69265276, val acc: 0.51499999 (best 0.53999996), test acc: 0.47000000 (best 0.45999998)
In epoch 875, loss: 0.69260162, val acc: 0.51999998 (best 0.53999996), test acc: 0.46500000 (best 0.45999998)
In epoch 880, loss: 0.69255155, val acc: 0.51999998 (best 0.53999996), test acc: 0.46500000 (best 0.45999998)
In epoch 885, loss: 0.69250512, val acc: 0.51499999 (best 0.53999996), test acc: 0.46500000 (best 0.45999998)
In epoch 890, loss: 0.69246137, val acc: 0.51999998 (best 0.53999996), test acc: 0.46500000 (best 0.45999998)
In epoch 895, loss: 0.69241792, val acc: 0.51999998 (best 0.53999996), test acc: 0.46500000 (best 0.45999998)
In epoch 900, loss: 0.69237709, val acc: 0.51999998 (best 0.53999996), test acc: 0.46500000 (best 0.45999998)
In epoch 905, loss: 0.69233721, val acc: 0.51999998 (best 0.53999996), test acc: 0.45999998 (best 0.45999998)
In epoch 910, loss: 0.69229662, val acc: 0.51999998 (best 0.53999996), test acc: 0.45999998 (best 0.45999998)
In epoch 915, loss: 0.69225693, val acc: 0.52499998 (best 0.53999996), test acc: 0.46500000 (best 0.45999998)
In epoch 920, loss: 0.69221914, val acc: 0.51999998 (best 0.53999996), test acc: 0.46500000 (best 0.45999998)
In epoch 925, loss: 0.69218206, val acc: 0.51999998 (best 0.53999996), test acc: 0.46500000 (best 0.45999998)
In epoch 930, loss: 0.69214731, val acc: 0.53499997 (best 0.53999996), test acc: 0.45999998 (best 0.45999998)
In epoch 935, loss: 0.69211280, val acc: 0.53499997 (best 0.53999996), test acc: 0.45999998 (best 0.45999998)
In epoch 940, loss: 0.69207799, val acc: 0.53499997 (best 0.53999996), test acc: 0.45999998 (best 0.45999998)
In epoch 945, loss: 0.69204628, val acc: 0.53499997 (best 0.53999996), test acc: 0.46500000 (best 0.45999998)
In epoch 950, loss: 0.69201708, val acc: 0.53499997 (best 0.53999996), test acc: 0.45999998 (best 0.45999998)
In epoch 955, loss: 0.69198942, val acc: 0.53499997 (best 0.53999996), test acc: 0.45499998 (best 0.45999998)
In epoch 960, loss: 0.69196296, val acc: 0.53499997 (best 0.53999996), test acc: 0.45999998 (best 0.45999998)
In epoch 965, loss: 0.69193602, val acc: 0.53499997 (best 0.53999996), test acc: 0.45999998 (best 0.45999998)
In epoch 970, loss: 0.69190824, val acc: 0.53499997 (best 0.53999996), test acc: 0.46500000 (best 0.45999998)
In epoch 975, loss: 0.69188291, val acc: 0.53499997 (best 0.53999996), test acc: 0.46500000 (best 0.45999998)
In epoch 980, loss: 0.69185603, val acc: 0.53999996 (best 0.53999996), test acc: 0.46500000 (best 0.45999998)
In epoch 985, loss: 0.69183111, val acc: 0.53999996 (best 0.53999996), test acc: 0.46500000 (best 0.45999998)
In epoch 990, loss: 0.69180596, val acc: 0.53999996 (best 0.53999996), test acc: 0.46500000 (best 0.45999998)
In epoch 995, loss: 0.69178164, val acc: 0.54500002 (best 0.54500002), test acc: 0.45999998 (best 0.45999998)
In epoch 1000, loss: 0.69175887, val acc: 0.53999996 (best 0.54500002), test acc: 0.46500000 (best 0.45999998)
In epoch 1005, loss: 0.69173682, val acc: 0.54500002 (best 0.54500002), test acc: 0.46500000 (best 0.45999998)
In epoch 1010, loss: 0.69171607, val acc: 0.54500002 (best 0.54500002), test acc: 0.46500000 (best 0.45999998)
In epoch 1015, loss: 0.69169754, val acc: 0.53999996 (best 0.54500002), test acc: 0.46500000 (best 0.45999998)
In epoch 1020, loss: 0.69167662, val acc: 0.54500002 (best 0.54500002), test acc: 0.46500000 (best 0.45999998)
In epoch 1025, loss: 0.69165701, val acc: 0.54500002 (best 0.54500002), test acc: 0.46500000 (best 0.45999998)
In epoch 1030, loss: 0.69163787, val acc: 0.53999996 (best 0.54500002), test acc: 0.46500000 (best 0.45999998)
In epoch 1035, loss: 0.69161963, val acc: 0.54500002 (best 0.54500002), test acc: 0.46500000 (best 0.45999998)
In epoch 1040, loss: 0.69160128, val acc: 0.54500002 (best 0.54500002), test acc: 0.47000000 (best 0.45999998)
In epoch 1045, loss: 0.69158280, val acc: 0.53999996 (best 0.54500002), test acc: 0.47000000 (best 0.45999998)
In epoch 1050, loss: 0.69156384, val acc: 0.54500002 (best 0.55000001), test acc: 0.47000000 (best 0.47499999)
In epoch 1055, loss: 0.69154418, val acc: 0.53999996 (best 0.55000001), test acc: 0.47000000 (best 0.47499999)
In epoch 1060, loss: 0.69152540, val acc: 0.53999996 (best 0.55500001), test acc: 0.47000000 (best 0.47000000)
In epoch 1065, loss: 0.69150734, val acc: 0.55000001 (best 0.55500001), test acc: 0.47499999 (best 0.47000000)
In epoch 1070, loss: 0.69148982, val acc: 0.55000001 (best 0.55500001), test acc: 0.47499999 (best 0.47000000)
In epoch 1075, loss: 0.69147509, val acc: 0.54500002 (best 0.55500001), test acc: 0.47999999 (best 0.47000000)
In epoch 1080, loss: 0.69145638, val acc: 0.55000001 (best 0.55500001), test acc: 0.47000000 (best 0.47000000)
In epoch 1085, loss: 0.69144011, val acc: 0.55000001 (best 0.55500001), test acc: 0.47000000 (best 0.47000000)
In epoch 1090, loss: 0.69142842, val acc: 0.54500002 (best 0.56000000), test acc: 0.48499998 (best 0.47000000)
In epoch 1095, loss: 0.69140851, val acc: 0.55500001 (best 0.56000000), test acc: 0.47000000 (best 0.47000000)
In epoch 1100, loss: 0.69139153, val acc: 0.56000000 (best 0.56500000), test acc: 0.47499999 (best 0.47499999)
In epoch 1105, loss: 0.69137847, val acc: 0.55500001 (best 0.56500000), test acc: 0.47000000 (best 0.47499999)
In epoch 1110, loss: 0.69136411, val acc: 0.56000000 (best 0.56500000), test acc: 0.47000000 (best 0.47499999)
In epoch 1115, loss: 0.69134909, val acc: 0.56000000 (best 0.56500000), test acc: 0.47000000 (best 0.47499999)
In epoch 1120, loss: 0.69133520, val acc: 0.56000000 (best 0.56500000), test acc: 0.47000000 (best 0.47499999)
In epoch 1125, loss: 0.69131899, val acc: 0.56500000 (best 0.56500000), test acc: 0.47999999 (best 0.47499999)
In epoch 1130, loss: 0.69130570, val acc: 0.56500000 (best 0.56999999), test acc: 0.47499999 (best 0.48999998)
In epoch 1135, loss: 0.69129241, val acc: 0.56500000 (best 0.56999999), test acc: 0.47999999 (best 0.48999998)
In epoch 1140, loss: 0.69127977, val acc: 0.56000000 (best 0.56999999), test acc: 0.46500000 (best 0.48999998)
In epoch 1145, loss: 0.69126284, val acc: 0.56500000 (best 0.56999999), test acc: 0.47999999 (best 0.48999998)
In epoch 1150, loss: 0.69125044, val acc: 0.56500000 (best 0.56999999), test acc: 0.47499999 (best 0.48999998)
In epoch 1155, loss: 0.69123816, val acc: 0.56000000 (best 0.56999999), test acc: 0.47499999 (best 0.48999998)
In epoch 1160, loss: 0.69122666, val acc: 0.55500001 (best 0.56999999), test acc: 0.47999999 (best 0.48999998)
In epoch 1165, loss: 0.69121420, val acc: 0.55000001 (best 0.56999999), test acc: 0.47999999 (best 0.48999998)
In epoch 1170, loss: 0.69120246, val acc: 0.55000001 (best 0.56999999), test acc: 0.47999999 (best 0.48999998)
In epoch 1175, loss: 0.69119227, val acc: 0.55000001 (best 0.56999999), test acc: 0.47999999 (best 0.48999998)
In epoch 1180, loss: 0.69117945, val acc: 0.55500001 (best 0.56999999), test acc: 0.47000000 (best 0.48999998)
In epoch 1185, loss: 0.69117075, val acc: 0.54500002 (best 0.56999999), test acc: 0.47499999 (best 0.48999998)
In epoch 1190, loss: 0.69116104, val acc: 0.54500002 (best 0.56999999), test acc: 0.47499999 (best 0.48999998)
In epoch 1195, loss: 0.69115144, val acc: 0.54500002 (best 0.56999999), test acc: 0.47999999 (best 0.48999998)
In epoch 1200, loss: 0.69114083, val acc: 0.54500002 (best 0.56999999), test acc: 0.47999999 (best 0.48999998)
In epoch 1205, loss: 0.69112915, val acc: 0.55000001 (best 0.56999999), test acc: 0.47499999 (best 0.48999998)
In epoch 1210, loss: 0.69112170, val acc: 0.54500002 (best 0.56999999), test acc: 0.47999999 (best 0.48999998)
In epoch 1215, loss: 0.69111067, val acc: 0.55000001 (best 0.56999999), test acc: 0.47999999 (best 0.48999998)
In epoch 1220, loss: 0.69110346, val acc: 0.55000001 (best 0.56999999), test acc: 0.47000000 (best 0.48999998)
In epoch 1225, loss: 0.69109094, val acc: 0.55000001 (best 0.56999999), test acc: 0.48499998 (best 0.48999998)
In epoch 1230, loss: 0.69108081, val acc: 0.53999996 (best 0.56999999), test acc: 0.47000000 (best 0.48999998)
In epoch 1235, loss: 0.69107407, val acc: 0.54500002 (best 0.56999999), test acc: 0.47999999 (best 0.48999998)
In epoch 1240, loss: 0.69105911, val acc: 0.54500002 (best 0.56999999), test acc: 0.47499999 (best 0.48999998)
In epoch 1245, loss: 0.69104886, val acc: 0.54500002 (best 0.56999999), test acc: 0.47499999 (best 0.48999998)
In epoch 1250, loss: 0.69104332, val acc: 0.54500002 (best 0.56999999), test acc: 0.47999999 (best 0.48999998)
In epoch 1255, loss: 0.69102943, val acc: 0.53999996 (best 0.56999999), test acc: 0.47999999 (best 0.48999998)
In epoch 1260, loss: 0.69101954, val acc: 0.53499997 (best 0.56999999), test acc: 0.48499998 (best 0.48999998)
In epoch 1265, loss: 0.69101596, val acc: 0.54500002 (best 0.56999999), test acc: 0.47999999 (best 0.48999998)
In epoch 1270, loss: 0.69100165, val acc: 0.54500002 (best 0.56999999), test acc: 0.48499998 (best 0.48999998)
In epoch 1275, loss: 0.69099253, val acc: 0.53999996 (best 0.56999999), test acc: 0.48499998 (best 0.48999998)
In epoch 1280, loss: 0.69098634, val acc: 0.53999996 (best 0.56999999), test acc: 0.48999998 (best 0.48999998)
In epoch 1285, loss: 0.69097799, val acc: 0.53999996 (best 0.56999999), test acc: 0.48999998 (best 0.48999998)
In epoch 1290, loss: 0.69096857, val acc: 0.52999997 (best 0.56999999), test acc: 0.48499998 (best 0.48999998)
In epoch 1295, loss: 0.69096154, val acc: 0.53499997 (best 0.56999999), test acc: 0.48499998 (best 0.48999998)
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In epoch 1300, loss: 0.69095492, val acc: 0.53499997 (best 0.56999999), test acc: 0.48999998 (best 0.48999998)
In epoch 1305, loss: 0.69094604, val acc: 0.52499998 (best 0.56999999), test acc: 0.48999998 (best 0.48999998)
In epoch 1310, loss: 0.69094050, val acc: 0.53499997 (best 0.56999999), test acc: 0.48999998 (best 0.48999998)
In epoch 1315, loss: 0.69093019, val acc: 0.52999997 (best 0.56999999), test acc: 0.49499997 (best 0.48999998)
In epoch 1320, loss: 0.69092447, val acc: 0.52499998 (best 0.56999999), test acc: 0.48999998 (best 0.48999998)
In epoch 1325, loss: 0.69091660, val acc: 0.52499998 (best 0.56999999), test acc: 0.48999998 (best 0.48999998)
In epoch 1330, loss: 0.69091278, val acc: 0.52499998 (best 0.56999999), test acc: 0.49499997 (best 0.48999998)
In epoch 1335, loss: 0.69090104, val acc: 0.52999997 (best 0.56999999), test acc: 0.47999999 (best 0.48999998)
In epoch 1340, loss: 0.69089389, val acc: 0.52499998 (best 0.56999999), test acc: 0.48499998 (best 0.48999998)
In epoch 1345, loss: 0.69088727, val acc: 0.51999998 (best 0.56999999), test acc: 0.48499998 (best 0.48999998)
In epoch 1350, loss: 0.69088119, val acc: 0.51999998 (best 0.56999999), test acc: 0.47999999 (best 0.48999998)
In epoch 1355, loss: 0.69087541, val acc: 0.51999998 (best 0.56999999), test acc: 0.47999999 (best 0.48999998)
In epoch 1360, loss: 0.69086897, val acc: 0.51999998 (best 0.56999999), test acc: 0.47999999 (best 0.48999998)
In epoch 1365, loss: 0.69086105, val acc: 0.51999998 (best 0.56999999), test acc: 0.47999999 (best 0.48999998)
In epoch 1370, loss: 0.69085431, val acc: 0.51999998 (best 0.56999999), test acc: 0.47999999 (best 0.48999998)
In epoch 1375, loss: 0.69084775, val acc: 0.51999998 (best 0.56999999), test acc: 0.47999999 (best 0.48999998)
In epoch 1380, loss: 0.69084001, val acc: 0.52499998 (best 0.56999999), test acc: 0.48999998 (best 0.48999998)
In epoch 1385, loss: 0.69083667, val acc: 0.51999998 (best 0.56999999), test acc: 0.47999999 (best 0.48999998)
In epoch 1390, loss: 0.69082999, val acc: 0.51999998 (best 0.56999999), test acc: 0.48999998 (best 0.48999998)
In epoch 1395, loss: 0.69082785, val acc: 0.55000001 (best 0.56999999), test acc: 0.50000000 (best 0.48999998)
In epoch 1400, loss: 0.69081897, val acc: 0.52999997 (best 0.56999999), test acc: 0.49499997 (best 0.48999998)
In epoch 1405, loss: 0.69081491, val acc: 0.53499997 (best 0.56999999), test acc: 0.50000000 (best 0.48999998)
In epoch 1410, loss: 0.69080931, val acc: 0.52999997 (best 0.56999999), test acc: 0.50000000 (best 0.48999998)
In epoch 1415, loss: 0.69080973, val acc: 0.54500002 (best 0.56999999), test acc: 0.49499997 (best 0.48999998)
In epoch 1420, loss: 0.69080061, val acc: 0.52499998 (best 0.56999999), test acc: 0.49499997 (best 0.48999998)
In epoch 1425, loss: 0.69079691, val acc: 0.52499998 (best 0.56999999), test acc: 0.50000000 (best 0.48999998)
In epoch 1430, loss: 0.69079900, val acc: 0.51499999 (best 0.56999999), test acc: 0.48999998 (best 0.48999998)
In epoch 1435, loss: 0.69079053, val acc: 0.53499997 (best 0.56999999), test acc: 0.50000000 (best 0.48999998)
In epoch 1440, loss: 0.69078583, val acc: 0.52499998 (best 0.56999999), test acc: 0.49499997 (best 0.48999998)
In epoch 1445, loss: 0.69078273, val acc: 0.53499997 (best 0.56999999), test acc: 0.50000000 (best 0.48999998)
In epoch 1450, loss: 0.69077981, val acc: 0.52499998 (best 0.56999999), test acc: 0.50500000 (best 0.48999998)
In epoch 1455, loss: 0.69077712, val acc: 0.52499998 (best 0.56999999), test acc: 0.50000000 (best 0.48999998)
In epoch 1460, loss: 0.69077611, val acc: 0.52499998 (best 0.56999999), test acc: 0.48999998 (best 0.48999998)
In epoch 1465, loss: 0.69076991, val acc: 0.52499998 (best 0.56999999), test acc: 0.50500000 (best 0.48999998)
In epoch 1470, loss: 0.69077039, val acc: 0.51999998 (best 0.56999999), test acc: 0.48999998 (best 0.48999998)
In epoch 1475, loss: 0.69076246, val acc: 0.52499998 (best 0.56999999), test acc: 0.49499997 (best 0.48999998)
In epoch 1480, loss: 0.69075942, val acc: 0.52499998 (best 0.56999999), test acc: 0.50000000 (best 0.48999998)
In epoch 1485, loss: 0.69076180, val acc: 0.52499998 (best 0.56999999), test acc: 0.49499997 (best 0.48999998)
In epoch 1490, loss: 0.69075340, val acc: 0.53499997 (best 0.56999999), test acc: 0.49499997 (best 0.48999998)
In epoch 1495, loss: 0.69074923, val acc: 0.52499998 (best 0.56999999), test acc: 0.49499997 (best 0.48999998)
In epoch 1500, loss: 0.69074637, val acc: 0.52499998 (best 0.56999999), test acc: 0.50500000 (best 0.48999998)
In epoch 1505, loss: 0.69074363, val acc: 0.52499998 (best 0.56999999), test acc: 0.50000000 (best 0.48999998)
In epoch 1510, loss: 0.69073790, val acc: 0.52499998 (best 0.56999999), test acc: 0.49499997 (best 0.48999998)
In epoch 1515, loss: 0.69073617, val acc: 0.52499998 (best 0.56999999), test acc: 0.50500000 (best 0.48999998)
In epoch 1520, loss: 0.69073111, val acc: 0.52499998 (best 0.56999999), test acc: 0.50500000 (best 0.48999998)
In epoch 1525, loss: 0.69072568, val acc: 0.53499997 (best 0.56999999), test acc: 0.49499997 (best 0.48999998)
In epoch 1530, loss: 0.69072241, val acc: 0.53999996 (best 0.56999999), test acc: 0.49499997 (best 0.48999998)
In epoch 1535, loss: 0.69071740, val acc: 0.53499997 (best 0.56999999), test acc: 0.49499997 (best 0.48999998)
In epoch 1540, loss: 0.69072038, val acc: 0.51999998 (best 0.56999999), test acc: 0.49499997 (best 0.48999998)
In epoch 1545, loss: 0.69071084, val acc: 0.53999996 (best 0.56999999), test acc: 0.49499997 (best 0.48999998)
In epoch 1550, loss: 0.69070655, val acc: 0.52499998 (best 0.56999999), test acc: 0.49499997 (best 0.48999998)
In epoch 1555, loss: 0.69070435, val acc: 0.52499998 (best 0.56999999), test acc: 0.50500000 (best 0.48999998)
In epoch 1560, loss: 0.69070220, val acc: 0.52499998 (best 0.56999999), test acc: 0.50500000 (best 0.48999998)
In epoch 1565, loss: 0.69069725, val acc: 0.52999997 (best 0.56999999), test acc: 0.50000000 (best 0.48999998)
In epoch 1570, loss: 0.69069749, val acc: 0.51499999 (best 0.56999999), test acc: 0.50500000 (best 0.48999998)
In epoch 1575, loss: 0.69069237, val acc: 0.52499998 (best 0.56999999), test acc: 0.50000000 (best 0.48999998)
In epoch 1580, loss: 0.69068825, val acc: 0.52999997 (best 0.56999999), test acc: 0.50000000 (best 0.48999998)
In epoch 1585, loss: 0.69069040, val acc: 0.53499997 (best 0.56999999), test acc: 0.48999998 (best 0.48999998)
In epoch 1590, loss: 0.69068420, val acc: 0.51999998 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 1595, loss: 0.69068033, val acc: 0.52499998 (best 0.56999999), test acc: 0.50000000 (best 0.48999998)
In epoch 1600, loss: 0.69067937, val acc: 0.51499999 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 1605, loss: 0.69067568, val acc: 0.51999998 (best 0.56999999), test acc: 0.50000000 (best 0.48999998)
In epoch 1610, loss: 0.69067693, val acc: 0.53999996 (best 0.56999999), test acc: 0.48999998 (best 0.48999998)
In epoch 1615, loss: 0.69066948, val acc: 0.52999997 (best 0.56999999), test acc: 0.50500000 (best 0.48999998)
In epoch 1620, loss: 0.69066691, val acc: 0.52999997 (best 0.56999999), test acc: 0.50500000 (best 0.48999998)
In epoch 1625, loss: 0.69066530, val acc: 0.53499997 (best 0.56999999), test acc: 0.50000000 (best 0.48999998)
In epoch 1630, loss: 0.69066149, val acc: 0.52499998 (best 0.56999999), test acc: 0.50000000 (best 0.48999998)
In epoch 1635, loss: 0.69065887, val acc: 0.52499998 (best 0.56999999), test acc: 0.50000000 (best 0.48999998)
In epoch 1640, loss: 0.69065619, val acc: 0.52499998 (best 0.56999999), test acc: 0.50500000 (best 0.48999998)
In epoch 1645, loss: 0.69065475, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 1650, loss: 0.69065344, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 1655, loss: 0.69065094, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 1660, loss: 0.69064844, val acc: 0.52499998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 1665, loss: 0.69064611, val acc: 0.52999997 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 1670, loss: 0.69064391, val acc: 0.53499997 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 1675, loss: 0.69064200, val acc: 0.53499997 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 1680, loss: 0.69063950, val acc: 0.52999997 (best 0.56999999), test acc: 0.50500000 (best 0.48999998)
In epoch 1685, loss: 0.69063807, val acc: 0.52999997 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 1690, loss: 0.69063538, val acc: 0.52499998 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 1695, loss: 0.69063449, val acc: 0.52999997 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 1700, loss: 0.69063354, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 1705, loss: 0.69062990, val acc: 0.52499998 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 1710, loss: 0.69063097, val acc: 0.52499998 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 1715, loss: 0.69062722, val acc: 0.52999997 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 1720, loss: 0.69062859, val acc: 0.53999996 (best 0.56999999), test acc: 0.50500000 (best 0.48999998)
In epoch 1725, loss: 0.69062251, val acc: 0.52499998 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 1730, loss: 0.69062114, val acc: 0.52999997 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 1735, loss: 0.69061953, val acc: 0.52999997 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 1740, loss: 0.69061846, val acc: 0.53499997 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 1745, loss: 0.69061643, val acc: 0.53499997 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 1750, loss: 0.69061631, val acc: 0.53999996 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 1755, loss: 0.69061279, val acc: 0.52999997 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 1760, loss: 0.69061351, val acc: 0.53499997 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 1765, loss: 0.69060814, val acc: 0.53499997 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 1770, loss: 0.69060653, val acc: 0.53499997 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 1775, loss: 0.69061297, val acc: 0.51999998 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 1780, loss: 0.69060355, val acc: 0.52999997 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 1785, loss: 0.69060099, val acc: 0.53499997 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 1790, loss: 0.69060081, val acc: 0.53499997 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 1795, loss: 0.69059968, val acc: 0.53499997 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 1800, loss: 0.69059867, val acc: 0.52999997 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 1805, loss: 0.69059587, val acc: 0.53499997 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 1810, loss: 0.69059545, val acc: 0.52999997 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
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In epoch 1815, loss: 0.69059145, val acc: 0.53499997 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 1820, loss: 0.69059318, val acc: 0.52499998 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 1825, loss: 0.69058728, val acc: 0.53499997 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 1830, loss: 0.69058752, val acc: 0.53499997 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 1835, loss: 0.69058383, val acc: 0.53499997 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 1840, loss: 0.69058210, val acc: 0.53499997 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 1845, loss: 0.69058031, val acc: 0.53499997 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 1850, loss: 0.69057894, val acc: 0.52999997 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 1855, loss: 0.69057852, val acc: 0.52499998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 1860, loss: 0.69057548, val acc: 0.53499997 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 1865, loss: 0.69057620, val acc: 0.51999998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 1870, loss: 0.69057482, val acc: 0.51999998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 1875, loss: 0.69057333, val acc: 0.51999998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 1880, loss: 0.69057077, val acc: 0.51999998 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 1885, loss: 0.69057280, val acc: 0.51999998 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 1890, loss: 0.69056684, val acc: 0.53499997 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 1895, loss: 0.69056630, val acc: 0.52999997 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 1900, loss: 0.69056368, val acc: 0.53499997 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 1905, loss: 0.69056290, val acc: 0.53499997 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 1910, loss: 0.69056129, val acc: 0.53499997 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 1915, loss: 0.69055945, val acc: 0.52999997 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 1920, loss: 0.69055831, val acc: 0.53499997 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 1925, loss: 0.69055635, val acc: 0.53499997 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 1930, loss: 0.69055575, val acc: 0.52999997 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 1935, loss: 0.69055414, val acc: 0.52999997 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 1940, loss: 0.69055372, val acc: 0.52999997 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 1945, loss: 0.69055140, val acc: 0.52999997 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 1950, loss: 0.69055045, val acc: 0.52999997 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 1955, loss: 0.69054979, val acc: 0.52999997 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 1960, loss: 0.69054985, val acc: 0.52999997 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 1965, loss: 0.69054651, val acc: 0.52999997 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 1970, loss: 0.69054794, val acc: 0.52499998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 1975, loss: 0.69054252, val acc: 0.52999997 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 1980, loss: 0.69054163, val acc: 0.52999997 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 1985, loss: 0.69054133, val acc: 0.52999997 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 1990, loss: 0.69053912, val acc: 0.52999997 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 1995, loss: 0.69054240, val acc: 0.52999997 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 2000, loss: 0.69053632, val acc: 0.53499997 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 2005, loss: 0.69053483, val acc: 0.52999997 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 2010, loss: 0.69053346, val acc: 0.52999997 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 2015, loss: 0.69053221, val acc: 0.52499998 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 2020, loss: 0.69053155, val acc: 0.52999997 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2025, loss: 0.69053113, val acc: 0.52999997 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 2030, loss: 0.69052851, val acc: 0.52499998 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 2035, loss: 0.69052809, val acc: 0.52999997 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2040, loss: 0.69052690, val acc: 0.52999997 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2045, loss: 0.69052511, val acc: 0.53499997 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 2050, loss: 0.69052392, val acc: 0.53499997 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 2055, loss: 0.69052225, val acc: 0.52999997 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 2060, loss: 0.69052088, val acc: 0.53499997 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 2065, loss: 0.69052142, val acc: 0.52999997 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 2070, loss: 0.69051844, val acc: 0.53499997 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 2075, loss: 0.69051993, val acc: 0.52999997 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 2080, loss: 0.69051695, val acc: 0.52999997 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 2085, loss: 0.69051641, val acc: 0.52999997 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 2090, loss: 0.69051361, val acc: 0.52999997 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 2095, loss: 0.69051242, val acc: 0.52999997 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 2100, loss: 0.69051206, val acc: 0.52999997 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 2105, loss: 0.69051123, val acc: 0.52999997 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2110, loss: 0.69050986, val acc: 0.52499998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 2115, loss: 0.69050819, val acc: 0.52499998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 2120, loss: 0.69050676, val acc: 0.52499998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2125, loss: 0.69050521, val acc: 0.52499998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2130, loss: 0.69050360, val acc: 0.52999997 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2135, loss: 0.69050276, val acc: 0.53499997 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 2140, loss: 0.69050235, val acc: 0.52999997 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 2145, loss: 0.69049996, val acc: 0.53499997 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 2150, loss: 0.69050080, val acc: 0.52999997 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2155, loss: 0.69050008, val acc: 0.52999997 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2160, loss: 0.69049895, val acc: 0.52999997 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 2165, loss: 0.69049704, val acc: 0.52999997 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2170, loss: 0.69049489, val acc: 0.52999997 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 2175, loss: 0.69049406, val acc: 0.52999997 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2180, loss: 0.69049531, val acc: 0.52999997 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 2185, loss: 0.69049078, val acc: 0.52999997 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 2190, loss: 0.69049460, val acc: 0.52499998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 2195, loss: 0.69048727, val acc: 0.52499998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2200, loss: 0.69048619, val acc: 0.53499997 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 2205, loss: 0.69048643, val acc: 0.52999997 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 2210, loss: 0.69048393, val acc: 0.52999997 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2215, loss: 0.69048285, val acc: 0.52999997 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2220, loss: 0.69048101, val acc: 0.52499998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2225, loss: 0.69048011, val acc: 0.52999997 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2230, loss: 0.69047976, val acc: 0.51999998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 2235, loss: 0.69047850, val acc: 0.51999998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 2240, loss: 0.69047660, val acc: 0.52999997 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 2245, loss: 0.69047624, val acc: 0.51999998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 2250, loss: 0.69047391, val acc: 0.52999997 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2255, loss: 0.69047499, val acc: 0.51499999 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 2260, loss: 0.69047320, val acc: 0.51999998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 2265, loss: 0.69047028, val acc: 0.52499998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2270, loss: 0.69047272, val acc: 0.51499999 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 2275, loss: 0.69046801, val acc: 0.52499998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2280, loss: 0.69046748, val acc: 0.52499998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 2285, loss: 0.69046599, val acc: 0.53499997 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 2290, loss: 0.69046503, val acc: 0.52999997 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 2295, loss: 0.69046342, val acc: 0.52499998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2300, loss: 0.69046283, val acc: 0.52999997 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 2305, loss: 0.69046193, val acc: 0.52999997 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 2310, loss: 0.69046175, val acc: 0.52999997 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 2315, loss: 0.69045901, val acc: 0.53499997 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2320, loss: 0.69046015, val acc: 0.52999997 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 2325, loss: 0.69045806, val acc: 0.52999997 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
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In epoch 2330, loss: 0.69045645, val acc: 0.52999997 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 2335, loss: 0.69045442, val acc: 0.52999997 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2340, loss: 0.69045317, val acc: 0.52499998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2345, loss: 0.69045621, val acc: 0.51499999 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2350, loss: 0.69045228, val acc: 0.52999997 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 2355, loss: 0.69044960, val acc: 0.52999997 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2360, loss: 0.69045144, val acc: 0.50999999 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2365, loss: 0.69044787, val acc: 0.52499998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 2370, loss: 0.69044989, val acc: 0.53499997 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2375, loss: 0.69044518, val acc: 0.52499998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 2380, loss: 0.69044411, val acc: 0.52499998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 2385, loss: 0.69044495, val acc: 0.51999998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 2390, loss: 0.69044459, val acc: 0.50999999 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2395, loss: 0.69044340, val acc: 0.50999999 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2400, loss: 0.69044191, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2405, loss: 0.69044030, val acc: 0.51999998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 2410, loss: 0.69043916, val acc: 0.51999998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 2415, loss: 0.69043696, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2420, loss: 0.69043624, val acc: 0.51999998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 2425, loss: 0.69043493, val acc: 0.51999998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 2430, loss: 0.69043785, val acc: 0.50500000 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 2435, loss: 0.69043154, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2440, loss: 0.69043070, val acc: 0.51999998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 2445, loss: 0.69043428, val acc: 0.50500000 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 2450, loss: 0.69042897, val acc: 0.52999997 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2455, loss: 0.69042706, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2460, loss: 0.69042593, val acc: 0.51999998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 2465, loss: 0.69042641, val acc: 0.52999997 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2470, loss: 0.69042397, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2475, loss: 0.69042456, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2480, loss: 0.69042188, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2485, loss: 0.69042695, val acc: 0.53499997 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2490, loss: 0.69041955, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2495, loss: 0.69041818, val acc: 0.52499998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2500, loss: 0.69042724, val acc: 0.53499997 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 2505, loss: 0.69041765, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2510, loss: 0.69041789, val acc: 0.51499999 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 2515, loss: 0.69041616, val acc: 0.51499999 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 2520, loss: 0.69041520, val acc: 0.51499999 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 2525, loss: 0.69041324, val acc: 0.51999998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 2530, loss: 0.69041353, val acc: 0.50999999 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 2535, loss: 0.69040960, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2540, loss: 0.69040900, val acc: 0.51999998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 2545, loss: 0.69040906, val acc: 0.51499999 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 2550, loss: 0.69040644, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2555, loss: 0.69040924, val acc: 0.51999998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 2560, loss: 0.69040406, val acc: 0.51499999 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2565, loss: 0.69040293, val acc: 0.51499999 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2570, loss: 0.69040197, val acc: 0.51499999 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 2575, loss: 0.69040072, val acc: 0.51499999 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2580, loss: 0.69039965, val acc: 0.51499999 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2585, loss: 0.69039869, val acc: 0.51499999 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2590, loss: 0.69039786, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2595, loss: 0.69039643, val acc: 0.51499999 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 2600, loss: 0.69039589, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2605, loss: 0.69039512, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2610, loss: 0.69039518, val acc: 0.52499998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2615, loss: 0.69039339, val acc: 0.52499998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2620, loss: 0.69039291, val acc: 0.52499998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2625, loss: 0.69039392, val acc: 0.53499997 (best 0.56999999), test acc: 0.50500000 (best 0.48999998)
In epoch 2630, loss: 0.69039035, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2635, loss: 0.69039321, val acc: 0.53499997 (best 0.56999999), test acc: 0.50500000 (best 0.48999998)
In epoch 2640, loss: 0.69038689, val acc: 0.51499999 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2645, loss: 0.69038612, val acc: 0.50999999 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2650, loss: 0.69039160, val acc: 0.53499997 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2655, loss: 0.69038481, val acc: 0.51999998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 2660, loss: 0.69038260, val acc: 0.51499999 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2665, loss: 0.69038206, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2670, loss: 0.69038111, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2675, loss: 0.69038481, val acc: 0.53499997 (best 0.56999999), test acc: 0.50500000 (best 0.48999998)
In epoch 2680, loss: 0.69037849, val acc: 0.51499999 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2685, loss: 0.69037735, val acc: 0.51499999 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2690, loss: 0.69037634, val acc: 0.50999999 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2695, loss: 0.69037539, val acc: 0.50999999 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2700, loss: 0.69037455, val acc: 0.50999999 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 2705, loss: 0.69037366, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2710, loss: 0.69037253, val acc: 0.51499999 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2715, loss: 0.69037229, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2720, loss: 0.69036996, val acc: 0.50999999 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2725, loss: 0.69037074, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2730, loss: 0.69036859, val acc: 0.51999998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 2735, loss: 0.69036680, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2740, loss: 0.69036627, val acc: 0.51999998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 2745, loss: 0.69036508, val acc: 0.51999998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 2750, loss: 0.69036543, val acc: 0.51999998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 2755, loss: 0.69036484, val acc: 0.51999998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 2760, loss: 0.69036311, val acc: 0.51999998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 2765, loss: 0.69036502, val acc: 0.52499998 (best 0.56999999), test acc: 0.52999997 (best 0.48999998)
In epoch 2770, loss: 0.69035971, val acc: 0.51999998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 2775, loss: 0.69036174, val acc: 0.52499998 (best 0.56999999), test acc: 0.52999997 (best 0.48999998)
In epoch 2780, loss: 0.69035703, val acc: 0.50999999 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2785, loss: 0.69035584, val acc: 0.50999999 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2790, loss: 0.69035470, val acc: 0.51499999 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2795, loss: 0.69035363, val acc: 0.51499999 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2800, loss: 0.69035387, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2805, loss: 0.69035202, val acc: 0.51499999 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 2810, loss: 0.69035178, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2815, loss: 0.69034952, val acc: 0.50999999 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2820, loss: 0.69035077, val acc: 0.52499998 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 2825, loss: 0.69034958, val acc: 0.52499998 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 2830, loss: 0.69034898, val acc: 0.52499998 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 2835, loss: 0.69034630, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2840, loss: 0.69034904, val acc: 0.52999997 (best 0.56999999), test acc: 0.50500000 (best 0.48999998)
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In epoch 2845, loss: 0.69034296, val acc: 0.50999999 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2850, loss: 0.69034219, val acc: 0.51499999 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 2855, loss: 0.69034064, val acc: 0.50999999 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2860, loss: 0.69034266, val acc: 0.52499998 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 2865, loss: 0.69033933, val acc: 0.51999998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 2870, loss: 0.69033736, val acc: 0.51499999 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2875, loss: 0.69033700, val acc: 0.51999998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 2880, loss: 0.69033694, val acc: 0.51999998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 2885, loss: 0.69033408, val acc: 0.50999999 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 2890, loss: 0.69033384, val acc: 0.51499999 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 2895, loss: 0.69033206, val acc: 0.50999999 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2900, loss: 0.69033164, val acc: 0.51499999 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 2905, loss: 0.69033033, val acc: 0.51499999 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 2910, loss: 0.69033164, val acc: 0.52499998 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 2915, loss: 0.69032753, val acc: 0.51999998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 2920, loss: 0.69032651, val acc: 0.51999998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 2925, loss: 0.69032538, val acc: 0.51499999 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2930, loss: 0.69032449, val acc: 0.51499999 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 2935, loss: 0.69032484, val acc: 0.51999998 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 2940, loss: 0.69032204, val acc: 0.50999999 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 2945, loss: 0.69032365, val acc: 0.52499998 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 2950, loss: 0.69032133, val acc: 0.51499999 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 2955, loss: 0.69031930, val acc: 0.52499998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 2960, loss: 0.69031924, val acc: 0.51999998 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 2965, loss: 0.69031686, val acc: 0.52499998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 2970, loss: 0.69032365, val acc: 0.52999997 (best 0.56999999), test acc: 0.50500000 (best 0.48999998)
In epoch 2975, loss: 0.69031602, val acc: 0.51999998 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 2980, loss: 0.69031370, val acc: 0.51999998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 2985, loss: 0.69031531, val acc: 0.52499998 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 2990, loss: 0.69031197, val acc: 0.52999997 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 2995, loss: 0.69031495, val acc: 0.52499998 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 3000, loss: 0.69030958, val acc: 0.51999998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 3005, loss: 0.69030833, val acc: 0.51499999 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 3010, loss: 0.69030738, val acc: 0.51999998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 3015, loss: 0.69030762, val acc: 0.51999998 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3020, loss: 0.69030541, val acc: 0.51999998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 3025, loss: 0.69030577, val acc: 0.51999998 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3030, loss: 0.69030356, val acc: 0.51999998 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 3035, loss: 0.69030267, val acc: 0.51499999 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 3040, loss: 0.69030130, val acc: 0.51499999 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 3045, loss: 0.69030076, val acc: 0.51499999 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 3050, loss: 0.69030046, val acc: 0.51499999 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 3055, loss: 0.69029963, val acc: 0.51499999 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 3060, loss: 0.69029772, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 3065, loss: 0.69029790, val acc: 0.51999998 (best 0.56999999), test acc: 0.50500000 (best 0.48999998)
In epoch 3070, loss: 0.69029546, val acc: 0.51999998 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 3075, loss: 0.69029617, val acc: 0.51999998 (best 0.56999999), test acc: 0.50500000 (best 0.48999998)
In epoch 3080, loss: 0.69029462, val acc: 0.51999998 (best 0.56999999), test acc: 0.50500000 (best 0.48999998)
In epoch 3085, loss: 0.69029647, val acc: 0.52499998 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 3090, loss: 0.69029105, val acc: 0.51499999 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 3095, loss: 0.69029027, val acc: 0.51999998 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 3100, loss: 0.69028962, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 3105, loss: 0.69028836, val acc: 0.51999998 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 3110, loss: 0.69029021, val acc: 0.52499998 (best 0.56999999), test acc: 0.50500000 (best 0.48999998)
In epoch 3115, loss: 0.69028556, val acc: 0.51499999 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 3120, loss: 0.69028550, val acc: 0.51499999 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 3125, loss: 0.69028342, val acc: 0.52499998 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3130, loss: 0.69028246, val acc: 0.52499998 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3135, loss: 0.69028097, val acc: 0.51499999 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 3140, loss: 0.69028020, val acc: 0.51999998 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3145, loss: 0.69028032, val acc: 0.51999998 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3150, loss: 0.69027829, val acc: 0.51999998 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3155, loss: 0.69027674, val acc: 0.51999998 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3160, loss: 0.69027591, val acc: 0.51999998 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3165, loss: 0.69027382, val acc: 0.51999998 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3170, loss: 0.69027412, val acc: 0.51999998 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3175, loss: 0.69027251, val acc: 0.51999998 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3180, loss: 0.69027168, val acc: 0.51999998 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3185, loss: 0.69027245, val acc: 0.53499997 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3190, loss: 0.69027007, val acc: 0.51999998 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3195, loss: 0.69027185, val acc: 0.52999997 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3200, loss: 0.69026655, val acc: 0.51999998 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3205, loss: 0.69026875, val acc: 0.53499997 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3210, loss: 0.69026411, val acc: 0.51999998 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3215, loss: 0.69026315, val acc: 0.51999998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 3220, loss: 0.69026202, val acc: 0.51999998 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3225, loss: 0.69026107, val acc: 0.51999998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 3230, loss: 0.69026101, val acc: 0.51999998 (best 0.56999999), test acc: 0.50500000 (best 0.48999998)
In epoch 3235, loss: 0.69025993, val acc: 0.51999998 (best 0.56999999), test acc: 0.50500000 (best 0.48999998)
In epoch 3240, loss: 0.69025731, val acc: 0.51999998 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 3245, loss: 0.69025469, val acc: 0.52499998 (best 0.56999999), test acc: 0.50500000 (best 0.48999998)
In epoch 3250, loss: 0.69025099, val acc: 0.52499998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 3255, loss: 0.69025153, val acc: 0.51999998 (best 0.56999999), test acc: 0.50500000 (best 0.48999998)
In epoch 3260, loss: 0.69025099, val acc: 0.51999998 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 3265, loss: 0.69025010, val acc: 0.51999998 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 3270, loss: 0.69024843, val acc: 0.51999998 (best 0.56999999), test acc: 0.50500000 (best 0.48999998)
In epoch 3275, loss: 0.69024730, val acc: 0.51999998 (best 0.56999999), test acc: 0.50500000 (best 0.48999998)
In epoch 3280, loss: 0.69024569, val acc: 0.51999998 (best 0.56999999), test acc: 0.50500000 (best 0.48999998)
In epoch 3285, loss: 0.69024366, val acc: 0.52499998 (best 0.56999999), test acc: 0.50500000 (best 0.48999998)
In epoch 3290, loss: 0.69024241, val acc: 0.52499998 (best 0.56999999), test acc: 0.50500000 (best 0.48999998)
In epoch 3295, loss: 0.69024122, val acc: 0.52499998 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 3300, loss: 0.69024575, val acc: 0.53499997 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3305, loss: 0.69023824, val acc: 0.51999998 (best 0.56999999), test acc: 0.52999997 (best 0.48999998)
In epoch 3310, loss: 0.69023734, val acc: 0.51999998 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3315, loss: 0.69023705, val acc: 0.52999997 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3320, loss: 0.69023544, val acc: 0.52499998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 3325, loss: 0.69023466, val acc: 0.52499998 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 3330, loss: 0.69023317, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 3335, loss: 0.69023323, val acc: 0.52499998 (best 0.56999999), test acc: 0.50500000 (best 0.48999998)
In epoch 3340, loss: 0.69023234, val acc: 0.52499998 (best 0.56999999), test acc: 0.50500000 (best 0.48999998)
In epoch 3345, loss: 0.69023192, val acc: 0.52499998 (best 0.56999999), test acc: 0.50500000 (best 0.48999998)
In epoch 3350, loss: 0.69022977, val acc: 0.52499998 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 3355, loss: 0.69022965, val acc: 0.52499998 (best 0.56999999), test acc: 0.50500000 (best 0.48999998)
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In epoch 3360, loss: 0.69022995, val acc: 0.52499998 (best 0.56999999), test acc: 0.50500000 (best 0.48999998)
In epoch 3365, loss: 0.69022751, val acc: 0.52499998 (best 0.56999999), test acc: 0.50500000 (best 0.48999998)
In epoch 3370, loss: 0.69022924, val acc: 0.51499999 (best 0.56999999), test acc: 0.50000000 (best 0.48999998)
In epoch 3375, loss: 0.69022429, val acc: 0.52499998 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 3380, loss: 0.69022584, val acc: 0.52499998 (best 0.56999999), test acc: 0.50500000 (best 0.48999998)
In epoch 3385, loss: 0.69022155, val acc: 0.51999998 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3390, loss: 0.69022125, val acc: 0.52499998 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 3395, loss: 0.69021988, val acc: 0.51999998 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3400, loss: 0.69021928, val acc: 0.52999997 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3405, loss: 0.69021761, val acc: 0.52499998 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3410, loss: 0.69021749, val acc: 0.52999997 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3415, loss: 0.69021660, val acc: 0.53499997 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3420, loss: 0.69021624, val acc: 0.53499997 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3425, loss: 0.69021469, val acc: 0.53499997 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3430, loss: 0.69021326, val acc: 0.53499997 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3435, loss: 0.69021231, val acc: 0.53499997 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3440, loss: 0.69021571, val acc: 0.53499997 (best 0.56999999), test acc: 0.52999997 (best 0.48999998)
In epoch 3445, loss: 0.69020915, val acc: 0.52499998 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3450, loss: 0.69020808, val acc: 0.52499998 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3455, loss: 0.69020700, val acc: 0.52499998 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3460, loss: 0.69020724, val acc: 0.52999997 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3465, loss: 0.69020545, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 3470, loss: 0.69020426, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 3475, loss: 0.69020289, val acc: 0.51999998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 3480, loss: 0.69020200, val acc: 0.51999998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 3485, loss: 0.69020075, val acc: 0.52499998 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3490, loss: 0.69019967, val acc: 0.52499998 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3495, loss: 0.69020033, val acc: 0.52499998 (best 0.56999999), test acc: 0.50500000 (best 0.48999998)
In epoch 3500, loss: 0.69019771, val acc: 0.52499998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 3505, loss: 0.69019908, val acc: 0.52499998 (best 0.56999999), test acc: 0.50500000 (best 0.48999998)
In epoch 3510, loss: 0.69019723, val acc: 0.52499998 (best 0.56999999), test acc: 0.50500000 (best 0.48999998)
In epoch 3515, loss: 0.69019526, val acc: 0.53499997 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3520, loss: 0.69019473, val acc: 0.53499997 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3525, loss: 0.69019300, val acc: 0.52499998 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3530, loss: 0.69019789, val acc: 0.50999999 (best 0.56999999), test acc: 0.50500000 (best 0.48999998)
In epoch 3535, loss: 0.69019043, val acc: 0.51999998 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3540, loss: 0.69018918, val acc: 0.52499998 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3545, loss: 0.69019181, val acc: 0.53499997 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3550, loss: 0.69018877, val acc: 0.52499998 (best 0.56999999), test acc: 0.50500000 (best 0.48999998)
In epoch 3555, loss: 0.69018751, val acc: 0.52499998 (best 0.56999999), test acc: 0.50500000 (best 0.48999998)
In epoch 3560, loss: 0.69018793, val acc: 0.52999997 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3565, loss: 0.69018590, val acc: 0.53499997 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3570, loss: 0.69018519, val acc: 0.53499997 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3575, loss: 0.69018286, val acc: 0.53499997 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3580, loss: 0.69018263, val acc: 0.53499997 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3585, loss: 0.69018191, val acc: 0.53499997 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3590, loss: 0.69018120, val acc: 0.52999997 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3595, loss: 0.69018012, val acc: 0.52999997 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3600, loss: 0.69018000, val acc: 0.52999997 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 3605, loss: 0.69017828, val acc: 0.52999997 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3610, loss: 0.69017893, val acc: 0.53499997 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3615, loss: 0.69017500, val acc: 0.53999996 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3620, loss: 0.69017869, val acc: 0.52499998 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3625, loss: 0.69017166, val acc: 0.52499998 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3630, loss: 0.69017076, val acc: 0.51499999 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3635, loss: 0.69017005, val acc: 0.51999998 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3640, loss: 0.69016874, val acc: 0.51999998 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3645, loss: 0.69017065, val acc: 0.53499997 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 3650, loss: 0.69016767, val acc: 0.52499998 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 3655, loss: 0.69016558, val acc: 0.52499998 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3660, loss: 0.69016749, val acc: 0.53499997 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3665, loss: 0.69016433, val acc: 0.52499998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 3670, loss: 0.69016576, val acc: 0.51999998 (best 0.56999999), test acc: 0.50500000 (best 0.48999998)
In epoch 3675, loss: 0.69016260, val acc: 0.52499998 (best 0.56999999), test acc: 0.50500000 (best 0.48999998)
In epoch 3680, loss: 0.69016623, val acc: 0.50999999 (best 0.56999999), test acc: 0.50500000 (best 0.48999998)
In epoch 3685, loss: 0.69015938, val acc: 0.52499998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 3690, loss: 0.69015849, val acc: 0.52499998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 3695, loss: 0.69015753, val acc: 0.52499998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 3700, loss: 0.69015729, val acc: 0.52499998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 3705, loss: 0.69015527, val acc: 0.52499998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 3710, loss: 0.69015431, val acc: 0.52499998 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3715, loss: 0.69015431, val acc: 0.53999996 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3720, loss: 0.69015360, val acc: 0.53999996 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 3725, loss: 0.69015169, val acc: 0.51999998 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3730, loss: 0.69015175, val acc: 0.53499997 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 3735, loss: 0.69014990, val acc: 0.53499997 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3740, loss: 0.69015044, val acc: 0.52999997 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 3745, loss: 0.69015092, val acc: 0.52999997 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3750, loss: 0.69014823, val acc: 0.52999997 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 3755, loss: 0.69014859, val acc: 0.52999997 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3760, loss: 0.69014472, val acc: 0.53499997 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3765, loss: 0.69014496, val acc: 0.52999997 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 3770, loss: 0.69014299, val acc: 0.53499997 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 3775, loss: 0.69014543, val acc: 0.52499998 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3780, loss: 0.69014013, val acc: 0.51999998 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3785, loss: 0.69013947, val acc: 0.51999998 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3790, loss: 0.69013810, val acc: 0.52499998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 3795, loss: 0.69013709, val acc: 0.52499998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 3800, loss: 0.69013697, val acc: 0.52499998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 3805, loss: 0.69013643, val acc: 0.52499998 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 3810, loss: 0.69013411, val acc: 0.52499998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 3815, loss: 0.69013542, val acc: 0.52499998 (best 0.56999999), test acc: 0.50500000 (best 0.48999998)
In epoch 3820, loss: 0.69013458, val acc: 0.52499998 (best 0.56999999), test acc: 0.50500000 (best 0.48999998)
In epoch 3825, loss: 0.69013375, val acc: 0.52499998 (best 0.56999999), test acc: 0.50500000 (best 0.48999998)
In epoch 3830, loss: 0.69013160, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 3835, loss: 0.69013095, val acc: 0.52499998 (best 0.56999999), test acc: 0.50500000 (best 0.48999998)
In epoch 3840, loss: 0.69012785, val acc: 0.52499998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 3845, loss: 0.69012696, val acc: 0.52499998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 3850, loss: 0.69012648, val acc: 0.52999997 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 3855, loss: 0.69012469, val acc: 0.52499998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 3860, loss: 0.69012505, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 3865, loss: 0.69012380, val acc: 0.52499998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 3870, loss: 0.69012266, val acc: 0.52499998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
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In epoch 3875, loss: 0.69012070, val acc: 0.52499998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 3880, loss: 0.69012070, val acc: 0.51999998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 3885, loss: 0.69011819, val acc: 0.52499998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 3890, loss: 0.69011998, val acc: 0.52499998 (best 0.56999999), test acc: 0.50500000 (best 0.48999998)
In epoch 3895, loss: 0.69011736, val acc: 0.51999998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 3900, loss: 0.69011748, val acc: 0.52999997 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3905, loss: 0.69011438, val acc: 0.52999997 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 3910, loss: 0.69011360, val acc: 0.52999997 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 3915, loss: 0.69011301, val acc: 0.51999998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 3920, loss: 0.69011098, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 3925, loss: 0.69011086, val acc: 0.52999997 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 3930, loss: 0.69011062, val acc: 0.52999997 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3935, loss: 0.69010848, val acc: 0.52499998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 3940, loss: 0.69010901, val acc: 0.52999997 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3945, loss: 0.69010943, val acc: 0.52499998 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3950, loss: 0.69010681, val acc: 0.52999997 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3955, loss: 0.69010663, val acc: 0.52999997 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3960, loss: 0.69010329, val acc: 0.52499998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 3965, loss: 0.69010293, val acc: 0.52999997 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 3970, loss: 0.69010347, val acc: 0.52999997 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 3975, loss: 0.69010043, val acc: 0.52499998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 3980, loss: 0.69010466, val acc: 0.52499998 (best 0.56999999), test acc: 0.52999997 (best 0.48999998)
In epoch 3985, loss: 0.69009781, val acc: 0.52499998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 3990, loss: 0.69009680, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 3995, loss: 0.69009590, val acc: 0.52999997 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4000, loss: 0.69009477, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4005, loss: 0.69009471, val acc: 0.52999997 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4010, loss: 0.69009417, val acc: 0.51999998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4015, loss: 0.69009173, val acc: 0.51999998 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 4020, loss: 0.69009078, val acc: 0.52499998 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 4025, loss: 0.69009066, val acc: 0.51999998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4030, loss: 0.69009292, val acc: 0.51499999 (best 0.56999999), test acc: 0.50500000 (best 0.48999998)
In epoch 4035, loss: 0.69008768, val acc: 0.51999998 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 4040, loss: 0.69008696, val acc: 0.52499998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4045, loss: 0.69009328, val acc: 0.52999997 (best 0.56999999), test acc: 0.52999997 (best 0.48999998)
In epoch 4050, loss: 0.69008589, val acc: 0.51999998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4055, loss: 0.69008368, val acc: 0.52999997 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4060, loss: 0.69008482, val acc: 0.52999997 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 4065, loss: 0.69008368, val acc: 0.52999997 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 4070, loss: 0.69008082, val acc: 0.52999997 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4075, loss: 0.69008207, val acc: 0.52999997 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 4080, loss: 0.69007874, val acc: 0.52999997 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4085, loss: 0.69007975, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4090, loss: 0.69007742, val acc: 0.52999997 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 4095, loss: 0.69007736, val acc: 0.52499998 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 4100, loss: 0.69007468, val acc: 0.52499998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4105, loss: 0.69007659, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4110, loss: 0.69007361, val acc: 0.51999998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4115, loss: 0.69007576, val acc: 0.52499998 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 4120, loss: 0.69007063, val acc: 0.52999997 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 4125, loss: 0.69007003, val acc: 0.52499998 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 4130, loss: 0.69007021, val acc: 0.51999998 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 4135, loss: 0.69006759, val acc: 0.52499998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4140, loss: 0.69007230, val acc: 0.52999997 (best 0.56999999), test acc: 0.52999997 (best 0.48999998)
In epoch 4145, loss: 0.69006598, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4150, loss: 0.69006431, val acc: 0.51999998 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 4155, loss: 0.69007325, val acc: 0.51999998 (best 0.56999999), test acc: 0.50500000 (best 0.48999998)
In epoch 4160, loss: 0.69006419, val acc: 0.52499998 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 4165, loss: 0.69006491, val acc: 0.52499998 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 4170, loss: 0.69006270, val acc: 0.52999997 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 4175, loss: 0.69006258, val acc: 0.52499998 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 4180, loss: 0.69005966, val acc: 0.51999998 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 4185, loss: 0.69006163, val acc: 0.52999997 (best 0.56999999), test acc: 0.52999997 (best 0.48999998)
In epoch 4190, loss: 0.69005632, val acc: 0.52499998 (best 0.56999999), test acc: 0.50999999 (best 0.48999998)
In epoch 4195, loss: 0.69005537, val acc: 0.52499998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4200, loss: 0.69005692, val acc: 0.52999997 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 4205, loss: 0.69005311, val acc: 0.52499998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4210, loss: 0.69005227, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4215, loss: 0.69005096, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4220, loss: 0.69004989, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4225, loss: 0.69005018, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4230, loss: 0.69004846, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4235, loss: 0.69004798, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4240, loss: 0.69004601, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4245, loss: 0.69004667, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4250, loss: 0.69004625, val acc: 0.51499999 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4255, loss: 0.69004494, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4260, loss: 0.69004285, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4265, loss: 0.69004202, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4270, loss: 0.69004142, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4275, loss: 0.69004357, val acc: 0.51999998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4280, loss: 0.69003797, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4285, loss: 0.69004148, val acc: 0.51999998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4290, loss: 0.69003570, val acc: 0.52499998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4295, loss: 0.69003457, val acc: 0.52499998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4300, loss: 0.69003350, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4305, loss: 0.69003260, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4310, loss: 0.69003141, val acc: 0.51499999 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4315, loss: 0.69003057, val acc: 0.52499998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4320, loss: 0.69003105, val acc: 0.52499998 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 4325, loss: 0.69002843, val acc: 0.52499998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4330, loss: 0.69002974, val acc: 0.52499998 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 4335, loss: 0.69002718, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4340, loss: 0.69002581, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4345, loss: 0.69002479, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4350, loss: 0.69002336, val acc: 0.52499998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4355, loss: 0.69002324, val acc: 0.52499998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4360, loss: 0.69002265, val acc: 0.52499998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4365, loss: 0.69002211, val acc: 0.52499998 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 4370, loss: 0.69001961, val acc: 0.52499998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4375, loss: 0.69002032, val acc: 0.52499998 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 4380, loss: 0.69002050, val acc: 0.53499997 (best 0.56999999), test acc: 0.52999997 (best 0.48999998)
In epoch 4385, loss: 0.69001931, val acc: 0.53499997 (best 0.56999999), test acc: 0.52999997 (best 0.48999998)
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In epoch 4390, loss: 0.69001842, val acc: 0.53499997 (best 0.56999999), test acc: 0.52999997 (best 0.48999998)
In epoch 4395, loss: 0.69001698, val acc: 0.52999997 (best 0.56999999), test acc: 0.52999997 (best 0.48999998)
In epoch 4400, loss: 0.69001651, val acc: 0.53499997 (best 0.56999999), test acc: 0.52999997 (best 0.48999998)
In epoch 4405, loss: 0.69001448, val acc: 0.52499998 (best 0.56999999), test acc: 0.52999997 (best 0.48999998)
In epoch 4410, loss: 0.69001406, val acc: 0.52999997 (best 0.56999999), test acc: 0.52999997 (best 0.48999998)
In epoch 4415, loss: 0.69001120, val acc: 0.52499998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4420, loss: 0.69001329, val acc: 0.52999997 (best 0.56999999), test acc: 0.52999997 (best 0.48999998)
In epoch 4425, loss: 0.69000852, val acc: 0.52499998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4430, loss: 0.69001114, val acc: 0.52999997 (best 0.56999999), test acc: 0.52999997 (best 0.48999998)
In epoch 4435, loss: 0.69000643, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4440, loss: 0.69000518, val acc: 0.50999999 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4445, loss: 0.69000417, val acc: 0.51499999 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4450, loss: 0.69000322, val acc: 0.51999998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4455, loss: 0.69000238, val acc: 0.52499998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4460, loss: 0.69000113, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4465, loss: 0.69000036, val acc: 0.52499998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4470, loss: 0.69000024, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4475, loss: 0.68999869, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4480, loss: 0.68999791, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4485, loss: 0.68999654, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4490, loss: 0.68999588, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4495, loss: 0.68999428, val acc: 0.51499999 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4500, loss: 0.68999422, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4505, loss: 0.68999344, val acc: 0.51499999 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4510, loss: 0.68999338, val acc: 0.51499999 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4515, loss: 0.68999100, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4520, loss: 0.68999147, val acc: 0.51499999 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4525, loss: 0.68999028, val acc: 0.51499999 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4530, loss: 0.68999201, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4535, loss: 0.68998700, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4540, loss: 0.68999219, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4545, loss: 0.68998438, val acc: 0.51999998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4550, loss: 0.68998319, val acc: 0.51499999 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4555, loss: 0.68998492, val acc: 0.51499999 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4560, loss: 0.68998253, val acc: 0.52999997 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4565, loss: 0.68998033, val acc: 0.51999998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4570, loss: 0.68998098, val acc: 0.52999997 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 4575, loss: 0.68997908, val acc: 0.51999998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4580, loss: 0.68998301, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4585, loss: 0.68997633, val acc: 0.51999998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4590, loss: 0.68997556, val acc: 0.51499999 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4595, loss: 0.68997645, val acc: 0.51499999 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4600, loss: 0.68997353, val acc: 0.51999998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4605, loss: 0.68997270, val acc: 0.51499999 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4610, loss: 0.68997145, val acc: 0.51999998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4615, loss: 0.68997109, val acc: 0.51999998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4620, loss: 0.68997121, val acc: 0.52999997 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 4625, loss: 0.68996924, val acc: 0.51999998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4630, loss: 0.68996882, val acc: 0.52999997 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 4635, loss: 0.68996638, val acc: 0.51999998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4640, loss: 0.68996650, val acc: 0.53499997 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 4645, loss: 0.68996531, val acc: 0.51999998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4650, loss: 0.68996519, val acc: 0.52999997 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 4655, loss: 0.68996245, val acc: 0.51999998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4660, loss: 0.68996191, val acc: 0.51499999 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4665, loss: 0.68996269, val acc: 0.51499999 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4670, loss: 0.68996245, val acc: 0.51499999 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4675, loss: 0.68996054, val acc: 0.51499999 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4680, loss: 0.68995959, val acc: 0.51499999 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4685, loss: 0.68995702, val acc: 0.51499999 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4690, loss: 0.68995613, val acc: 0.51499999 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4695, loss: 0.68996078, val acc: 0.52999997 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4700, loss: 0.68995386, val acc: 0.51999998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4705, loss: 0.68995255, val acc: 0.51999998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4710, loss: 0.68995166, val acc: 0.51999998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4715, loss: 0.68995064, val acc: 0.51999998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4720, loss: 0.68995005, val acc: 0.51499999 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4725, loss: 0.68995064, val acc: 0.51499999 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4730, loss: 0.68994856, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4735, loss: 0.68994868, val acc: 0.51499999 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4740, loss: 0.68994635, val acc: 0.50999999 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4745, loss: 0.68994683, val acc: 0.51499999 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4750, loss: 0.68994594, val acc: 0.51499999 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4755, loss: 0.68994772, val acc: 0.51999998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4760, loss: 0.68994224, val acc: 0.50999999 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4765, loss: 0.68994302, val acc: 0.51499999 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4770, loss: 0.68993998, val acc: 0.51999998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4775, loss: 0.68993998, val acc: 0.51499999 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4780, loss: 0.68993849, val acc: 0.51999998 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 4785, loss: 0.68993735, val acc: 0.51499999 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4790, loss: 0.68993628, val acc: 0.51499999 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4795, loss: 0.68993497, val acc: 0.51499999 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4800, loss: 0.68993413, val acc: 0.51499999 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4805, loss: 0.68993342, val acc: 0.51499999 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4810, loss: 0.68993378, val acc: 0.52999997 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 4815, loss: 0.68993151, val acc: 0.51999998 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 4820, loss: 0.68993211, val acc: 0.52999997 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4825, loss: 0.68993235, val acc: 0.52999997 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 4830, loss: 0.68993104, val acc: 0.52999997 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4835, loss: 0.68993014, val acc: 0.52999997 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4840, loss: 0.68992829, val acc: 0.52999997 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4845, loss: 0.68992728, val acc: 0.52999997 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4850, loss: 0.68992525, val acc: 0.52499998 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 4855, loss: 0.68992651, val acc: 0.52999997 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4860, loss: 0.68992323, val acc: 0.52499998 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 4865, loss: 0.68992311, val acc: 0.52999997 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4870, loss: 0.68992013, val acc: 0.51499999 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4875, loss: 0.68991911, val acc: 0.51499999 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4880, loss: 0.68991929, val acc: 0.50999999 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4885, loss: 0.68991870, val acc: 0.52499998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4890, loss: 0.68991601, val acc: 0.51499999 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4895, loss: 0.68991852, val acc: 0.52999997 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4900, loss: 0.68991399, val acc: 0.51499999 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
```
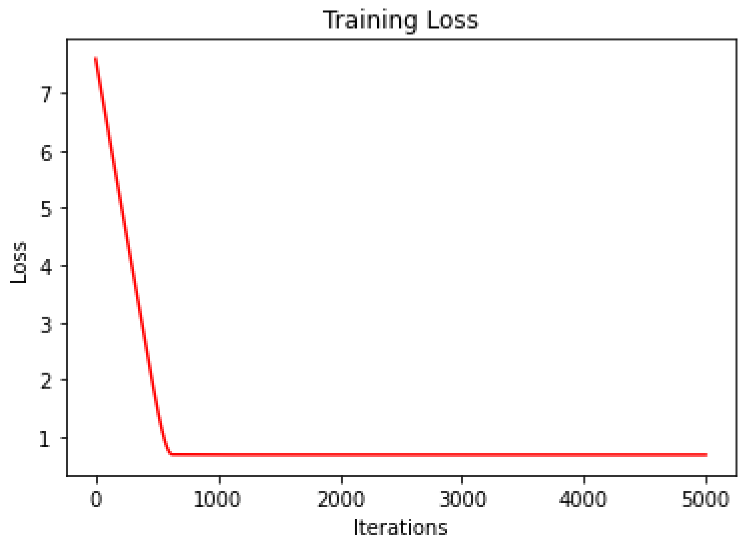
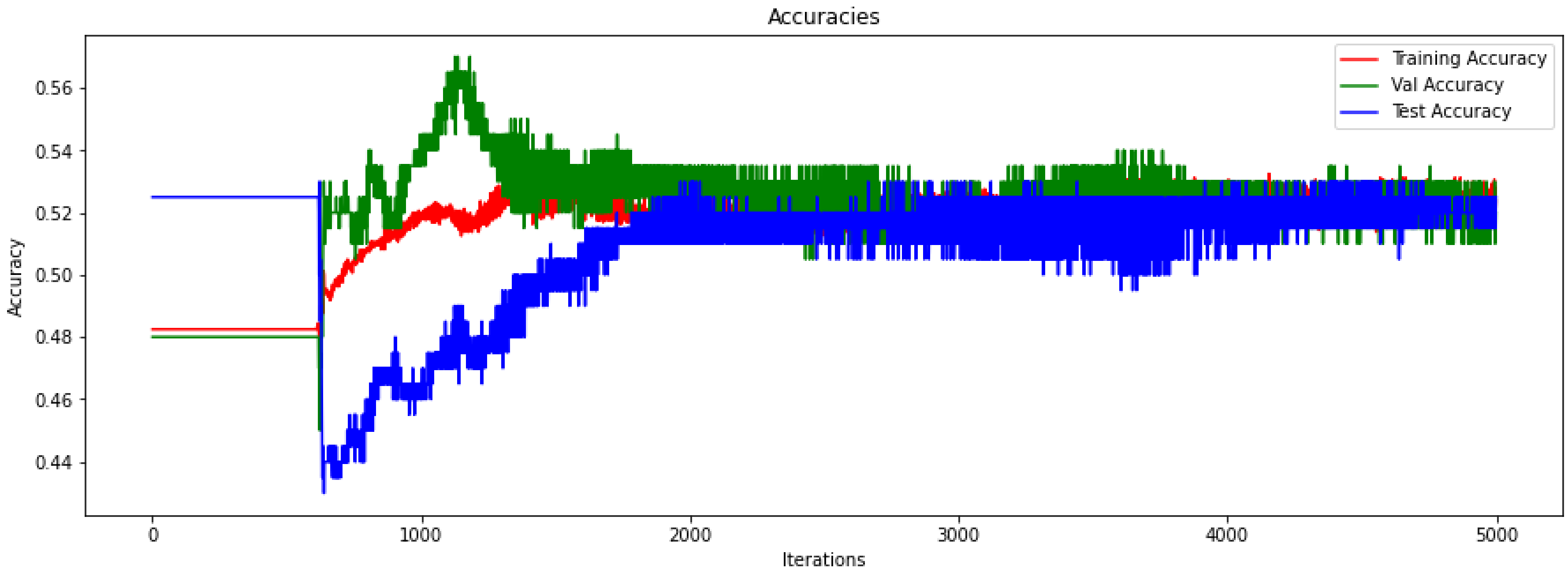

```
In epoch 4905, loss: 0.68991303, val acc: 0.51499999 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4910, loss: 0.68991208, val acc: 0.50999999 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4915, loss: 0.68991226, val acc: 0.51499999 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4920, loss: 0.68991113, val acc: 0.51499999 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4925, loss: 0.68991119, val acc: 0.50999999 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4930, loss: 0.68990934, val acc: 0.50999999 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4935, loss: 0.68990844, val acc: 0.51499999 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4940, loss: 0.68990809, val acc: 0.50999999 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4945, loss: 0.68990862, val acc: 0.51499999 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4950, loss: 0.68990576, val acc: 0.50999999 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4955, loss: 0.68990868, val acc: 0.51999998 (best 0.56999999), test acc: 0.51499999 (best 0.48999998)
In epoch 4960, loss: 0.68990219, val acc: 0.51499999 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4965, loss: 0.68990189, val acc: 0.51999998 (best 0.56999999), test acc: 0.52499998 (best 0.48999998)
In epoch 4970, loss: 0.68990052, val acc: 0.52499998 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4975, loss: 0.68990219, val acc: 0.51499999 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4980, loss: 0.68989825, val acc: 0.51499999 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4985, loss: 0.68989730, val acc: 0.51499999 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4990, loss: 0.68989635, val acc: 0.51499999 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
In epoch 4995, loss: 0.68989527, val acc: 0.51499999 (best 0.56999999), test acc: 0.51999998 (best 0.48999998)
```

In [51]:
```
plt.plot(node_classif_losses, 'r-')
plt.title('Training Loss')
plt.xlabel('Iterations')
plt.ylabel('Loss')
plt.show()
```



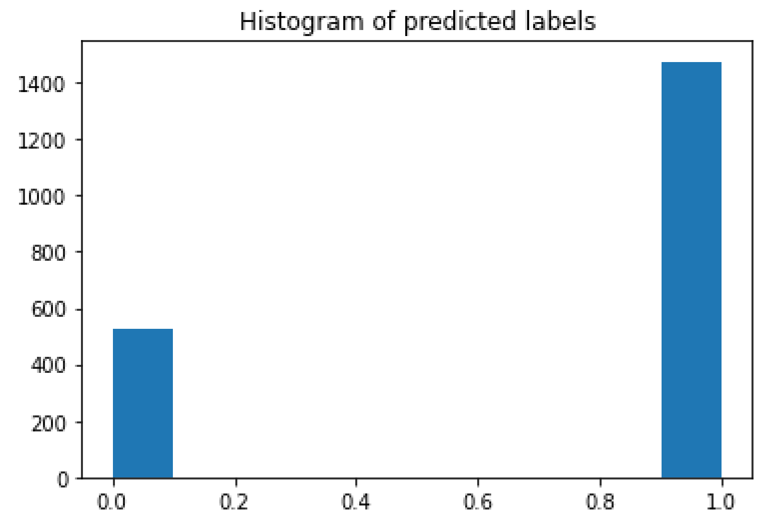
In [52]:
```
plt.figure(figsize=(15, 5))
plt.plot(node_classif_accs['train'], 'r-', label='Training Accuracy')
plt.plot(node_classif_accs['val'], 'g-', label='Val Accuracy')
plt.plot(node_classif_accs['test'], 'b-', label='Test Accuracy')
plt.title('Accuracies')
plt.xlabel('Iterations')
plt.ylabel('Accuracy')
plt.legend()
plt.show()
```



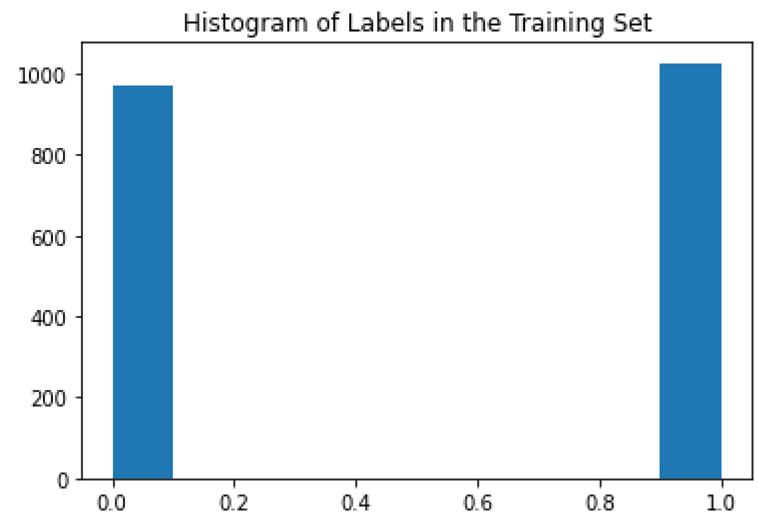
In [53]:
```
logits = node_classif_model(node_classif_graph, node_classif_graph.ndata['feat'])
pred = logits.argmax(1)
pred
```

Out[53]:
```
tensor([1, 0, 0,  ..., 1, 1, 1], device='cuda:0')
```

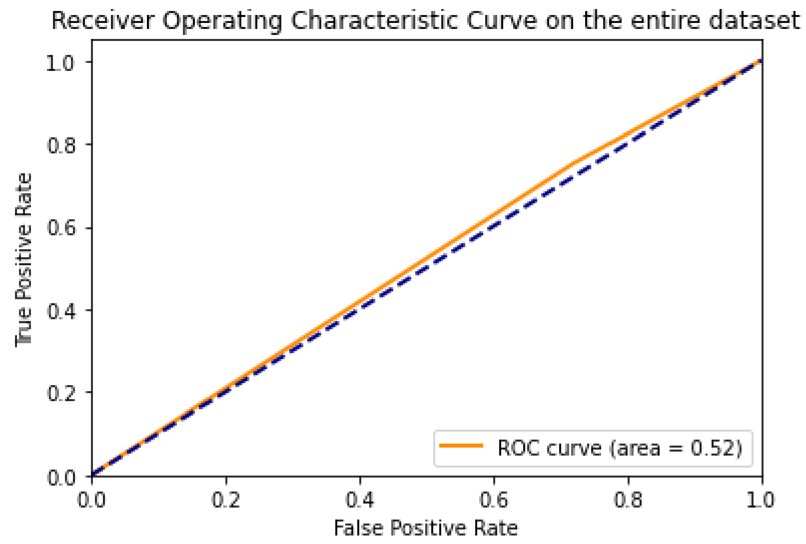
In [54]:
```
plt.hist(pred.cpu().numpy())
plt.title("Histogram of predicted labels")
plt.show()
```




```
In [55]:
label = node_classif_graph.ndata['label']
plt.hist(label.cpu().numpy())
plt.title("Histogram of Labels in the Training Set")
plt.show()
```




```
In [56]:
from sklearn.metrics import auc, roc_curve
fpr, tpr, _ = roc_curve(label.cpu().numpy(), pred.cpu().numpy())
roc_auc = auc(fpr, tpr)
plt.figure()
lw = 2
plt.plot(fpr, tpr, color='darkorange',
lw=lw, label='ROC curve (area = %0.2f)' % roc_auc)
plt.plot([0, 1], [0, 1], color='navy', lw=lw, linestyle='--')
plt.xlim([0.0, 1.0])
plt.ylim([0.0, 1.05])
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('Receiver Operating Characteristic Curve on the entire dataset')
plt.legend(loc="lower right")
plt.show()
```



Graph Classification

We now begin with this approach. Like before, we begin with creating a dataloader. We will fix the number of nodes in each graph (a tunable parameter) and then generate random graphs for each point in the dataset. We will give a label for each such graph.
In this approach, we can take the entire dataset provided as we can load the graphs in batches while training. But for the sake of fair comparison, we will take the same smaller dataset that we used for the Node Classification Approach.

```
In [17]: x_train_small[0].shape
```

```
Out[17]: (4,)
```

```
In [18]:
class GraphClassificationDataset(dgl.data.DGLDataset):
  """A Class to process and convert the numpy training data into Graphs so that it can be used in GNNs."""
  def __init__(self):
    super().__init__(name='graph_classification')
    self.num_classes = 2
    self.dim_nfeats = 4

  def process(self):
```

```
    self.graphs = []
    self.labels = []
    num_examples = len(x_train_small)
    num_train = int(num_examples * 0.8)
    num_val = int(num_examples * 0.1)
    train_mask = torch.zeros(num_examples, dtype=torch.bool)
    val_mask = torch.zeros(num_examples, dtype=torch.bool)
    test_mask = torch.zeros(num_examples, dtype=torch.bool)
    train_mask[:num_train] = True
    val_mask[num_train:num_train+num_val] = True
    test_mask[num_train+num_val:] = True
    self.train_mask = train_mask
    self.test_mask = test_mask
    self.val_mask = val_mask

    for id in range(len(x_train_small)):
      g = dgl.from_networkx(nx.generators.fast_gnp_random_graph(20, p=0.6))
      g.ndata['feat'] = torch.from_numpy(np.repeat(x_train_small[id].reshape(1,4),20,0))
      g.ndata['label'] = torch.LongTensor([y_train_small[id]]*20)
      self.graphs.append(g)
      self.labels.append(y_train_small[id])

    self.labels = torch.LongTensor(self.labels)

  def __getitem__(self, idx):
    return self.graphs[idx], self.labels[idx]

  def __len__(self):
    return len(self.graphs)
```

In [19]:

```
graph_classif_dataset = GraphClassificationDataset()
g_sample, label_sample = graph_classif_dataset[0]
print(g_sample, label_sample)
```

```
Graph(num_nodes=20, num_edges=234,
      ndata_schemes={'feat': Scheme(shape=(4,), dtype=torch.float32), 'label': Scheme(shape=(), dtype=torch.int64)}
      edata_schemes={}) tensor(1)
```

We will now create a dataloader

In [20]:

```
from dgl.dataloading import GraphDataLoader
from torch.utils.data.sampler import SubsetRandomSampler

num_examples = len(graph_classif_dataset)
num_train = int(num_examples * 0.8)
num_val = int(num_examples * 0.1)

train_sampler = SubsetRandomSampler(torch.arange(num_train))
val_sampler = SubsetRandomSampler(torch.arange(num_train, num_train+num_val))
test_sampler = SubsetRandomSampler(torch.arange(num_train+num_val, num_examples))

train_dataloader = GraphDataLoader(graph_classif_dataset, sampler=train_sampler, batch_size=5, drop_last=False)
val_dataloader = GraphDataLoader(graph_classif_dataset, sampler=val_sampler, batch_size=5, drop_last=False)
test_dataloader = GraphDataLoader(graph_classif_dataset, sampler=test_sampler, batch_size=5, drop_last=False)
```

In [21]:

```
it = iter(train_dataloader)
batch = next(it)
print(batch)
```

```
[Graph(num_nodes=100, num_edges=1132,
      ndata_schemes={'feat': Scheme(shape=(4,), dtype=torch.float32), 'label': Scheme(shape=(), dtype=torch.int64)}
      edata_schemes={}), tensor([1, 1, 1, 0, 1])]
```

In [22]:

```
batched_graph, labels = batch
print('Number of nodes for each graph element in the batch:', batched_graph.batch_num_nodes())
print('Number of edges for each graph element in the batch:', batched_graph.batch_num_edges())

# Recover the original graph elements from the minibatch
graphs = dgl.unbatch(batched_graph)
print('The original graphs in the minibatch:')
print(graphs)
```

```
Number of nodes for each graph element in the batch: tensor([20, 20, 20, 20, 20])
Number of edges for each graph element in the batch: tensor([228, 234, 218, 220, 232])
The original graphs in the minibatch:
[Graph(num_nodes=20, num_edges=228,
      ndata_schemes={'feat': Scheme(shape=(4,), dtype=torch.float32), 'label': Scheme(shape=(), dtype=torch.int64)}
      edata_schemes={}), Graph(num_nodes=20, num_edges=234,
      ndata_schemes={'feat': Scheme(shape=(4,), dtype=torch.float32), 'label': Scheme(shape=(), dtype=torch.int64)}
      edata_schemes={}), Graph(num_nodes=20, num_edges=218,
      ndata_schemes={'feat': Scheme(shape=(4,), dtype=torch.float32), 'label': Scheme(shape=(), dtype=torch.int64)}
      edata_schemes={}), Graph(num_nodes=20, num_edges=220,
      ndata_schemes={'feat': Scheme(shape=(4,), dtype=torch.float32), 'label': Scheme(shape=(), dtype=torch.int64)}
      edata_schemes={}), Graph(num_nodes=20, num_edges=232,
      ndata_schemes={'feat': Scheme(shape=(4,), dtype=torch.float32), 'label': Scheme(shape=(), dtype=torch.int64)}
      edata_schemes={})]
```

Defining the Model

In [23]:

```
from dgl.nn import GraphConv

class GraphClassificationModel(torch.nn.Module):
  """A Model Class having the methods to implement and forward pass a GNN."""
  def __init__(self, in_feats, num_classes):
    super(GraphClassificationModel, self).__init__()
    self.conv1 = GraphConv(in_feats, 16)
    self.conv2 = GraphConv(16, 32)
```

```python
    self.conv3 = GraphConv(32, num_classes)
    # self.conv3 = GraphConv(32, 64)
    # self.conv4 = GraphConv(64, num_classes)

  def forward(self, g, in_feat):
    h = self.conv1(g, in_feat)
    h = torch.nn.functional.relu(h)
    h = self.conv2(g, h)
    h = torch.nn.functional.relu(h)
    h = self.conv3(g, h)
    # h = torch.nn.functional.relu(h)
    # h = self.conv4(g, h)
    g.ndata['h'] = h
    return dgl.mean_nodes(g, 'h')
```

In [24]:

```python
graph_classif_model = GraphClassificationModel(graph_classif_dataset.dim_nfeats, graph_classif_dataset.num_classes)
```

Defining the Training Loop

In [25]:

```python
def train(train_loader, val_loader, test_loader, model, num_epochs):
  """The function implementing the main train loop."""
  losses = []
  accs = {'train':[], 'val': [], 'test': []}
  optimizer = torch.optim.Adam(model.parameters(), lr=0.01, betas=(0.9, 0.9999))
  best_val_acc = 0.0
  best_test_acc = 0.0

  for e in range(num_epochs):
    train_acc_batch = []
    val_acc_batch = []
    test_acc_batch = []
    train_loss_batch = []
    for batched_graph, labels in train_loader:
      model.train()
      batched_graph, labels = batched_graph.to('cuda'), labels.to('cuda')
      logits = model(batched_graph, batched_graph.ndata['feat'].float())
      pred = logits.argmax(1)
      loss = torch.nn.functional.cross_entropy(logits, labels)
      train_loss_batch.append(loss)
      train_acc = (pred == labels).float().mean()
      train_acc_batch.append(train_acc)
      with torch.no_grad():
        optimizer.zero_grad()
        loss.backward()
        optimizer.step()
    accs['train'].append(sum(train_acc_batch) / len(train_acc_batch))
    losses.append(sum(train_loss_batch) / len(train_loss_batch))

    model.eval()
    for batched_graph_val, labels_val in val_loader:
      batched_graph_val, labels_val = batched_graph_val.to('cuda'), labels_val.to('cuda')
      logits_val = model(batched_graph_val, batched_graph_val.ndata['feat'].float())
      pred_val = logits_val.argmax(1)
      val_acc = (pred_val == labels_val).float().mean()
      val_acc_batch.append(val_acc)
    accs['val'].append(sum(val_acc_batch) / len(val_acc_batch))

    for batched_graph_test, labels_test in test_loader:
      batched_graph_test, labels_test = batched_graph_test.to('cuda'), labels_test.to('cuda')
      logits_test = model(batched_graph_test, batched_graph_test.ndata['feat'].float())
      pred_test = logits_test.argmax(1)
      test_acc = (pred_test == labels_test).float().mean()
      test_acc_batch.append(test_acc)
    accs['test'].append(sum(test_acc_batch) / len(test_acc_batch))

    if best_val_acc < val_acc:
      best_val_acc = val_acc
      best_test_acc = test_acc

    if e % 5 == 0:
      print('In epoch {}, loss: {:.8f}, val acc: {:.8f} (best {:.8f}), test acc: {:.8f} (best {:.8f})'.format(
                e, loss, val_acc, best_val_acc, test_acc, best_test_acc))

  return losses, accs
```

In [26]:

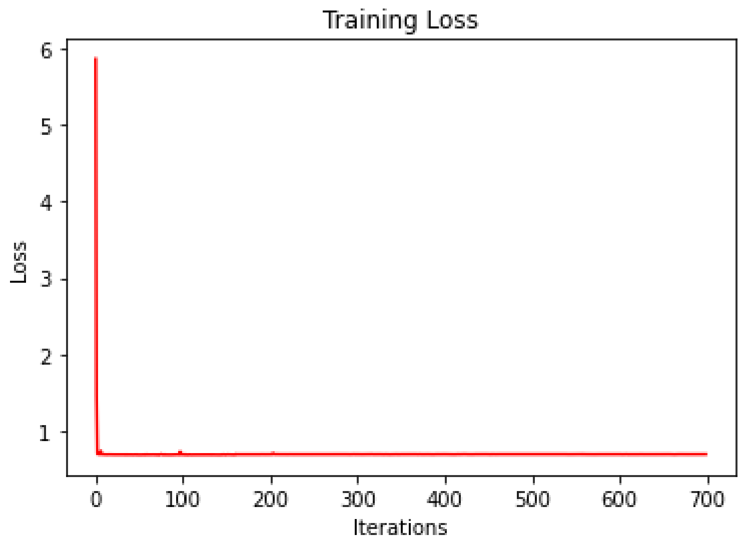
```python
graph_classif_model = graph_classif_model.to('cuda')
graph_classif_losses, graph_classif_accs = train(train_dataloader, val_dataloader, test_dataloader, graph_classif_model, 700)
```

```
In epoch 0, loss: 1.32255912, val acc: 0.80000001 (best 0.80000001), test acc: 0.80000001 (best 0.80000001)
In epoch 5, loss: 0.71140397, val acc: 0.80000001 (best 0.80000001), test acc: 0.20000000 (best 0.80000001)
In epoch 10, loss: 0.69860405, val acc: 0.40000001 (best 0.80000001), test acc: 0.60000002 (best 0.80000001)
In epoch 15, loss: 0.65682209, val acc: 0.60000002 (best 0.80000001), test acc: 0.80000001 (best 0.80000001)
In epoch 20, loss: 0.69134969, val acc: 0.60000002 (best 0.80000001), test acc: 0.20000000 (best 0.80000001)
In epoch 25, loss: 0.68840706, val acc: 0.40000001 (best 1.00000000), test acc: 0.40000001 (best 0.60000002)
In epoch 30, loss: 0.64081395, val acc: 0.80000001 (best 1.00000000), test acc: 0.60000002 (best 0.60000002)
In epoch 35, loss: 0.68934125, val acc: 0.40000001 (best 1.00000000), test acc: 0.40000001 (best 0.60000002)
In epoch 40, loss: 0.65559149, val acc: 0.60000002 (best 1.00000000), test acc: 0.40000001 (best 0.60000002)
In epoch 45, loss: 0.80932617, val acc: 0.40000001 (best 1.00000000), test acc: 0.40000001 (best 0.60000002)
In epoch 50, loss: 0.70110434, val acc: 0.60000002 (best 1.00000000), test acc: 0.00000000 (best 0.60000002)
In epoch 55, loss: 0.60884756, val acc: 0.20000000 (best 1.00000000), test acc: 0.40000001 (best 0.60000002)
In epoch 60, loss: 0.78330880, val acc: 0.40000001 (best 1.00000000), test acc: 0.60000002 (best 0.60000002)
In epoch 65, loss: 0.61864960, val acc: 0.20000000 (best 1.00000000), test acc: 1.00000000 (best 0.60000002)
In epoch 70, loss: 0.65097696, val acc: 0.40000001 (best 1.00000000), test acc: 0.40000001 (best 0.60000002)
In epoch 75, loss: 0.68667787, val acc: 0.80000001 (best 1.00000000), test acc: 0.40000001 (best 0.60000002)
In epoch 80, loss: 0.71602374, val acc: 0.60000002 (best 1.00000000), test acc: 1.00000000 (best 0.60000002)
In epoch 85, loss: 0.71640110, val acc: 0.40000001 (best 1.00000000), test acc: 0.60000002 (best 0.60000002)
```

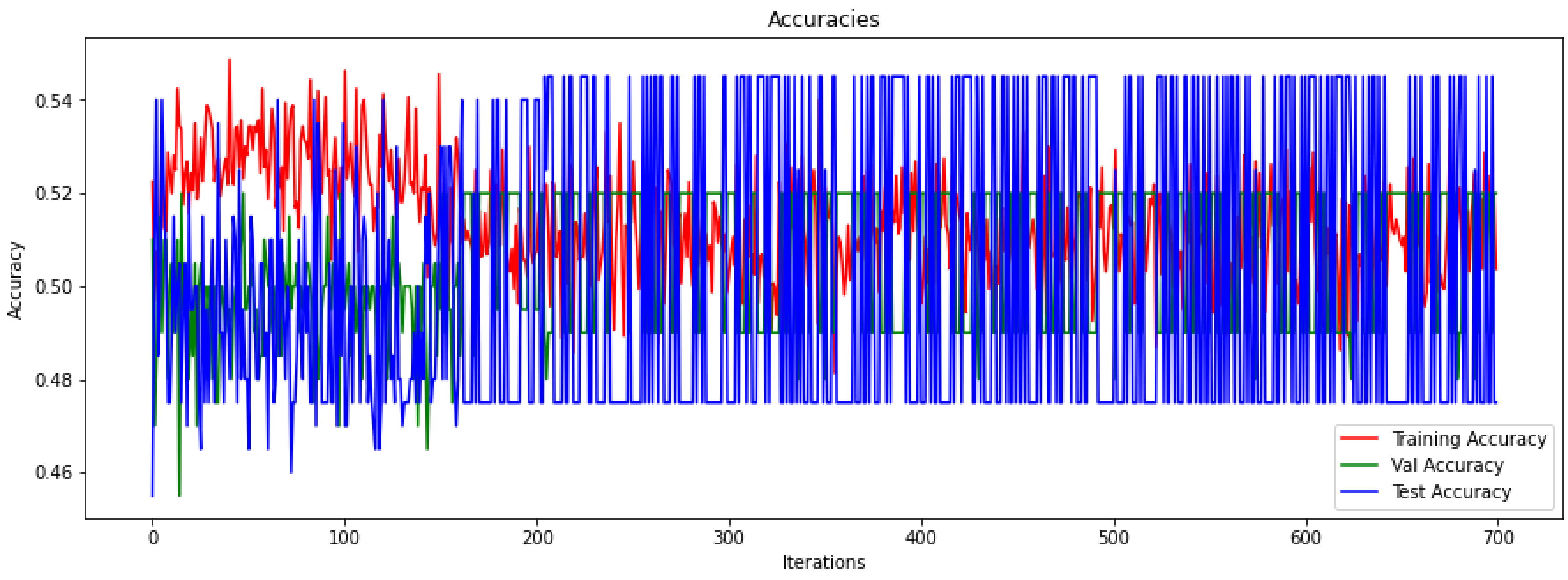
```
In epoch 90, loss: 0.61474597, val acc: 0.40000001 (best 1.00000000), test acc: 0.40000001 (best 0.60000002)
In epoch 95, loss: 0.52808022, val acc: 0.00000000 (best 1.00000000), test acc: 0.40000001 (best 0.60000002)
In epoch 100, loss: 0.68401468, val acc: 0.00000000 (best 1.00000000), test acc: 0.20000000 (best 0.60000002)
In epoch 105, loss: 0.74682379, val acc: 0.60000002 (best 1.00000000), test acc: 0.00000000 (best 0.60000002)
In epoch 110, loss: 0.72935390, val acc: 0.40000001 (best 1.00000000), test acc: 0.40000001 (best 0.60000002)
In epoch 115, loss: 0.68621612, val acc: 0.60000002 (best 1.00000000), test acc: 0.60000002 (best 0.60000002)
In epoch 120, loss: 0.71008050, val acc: 0.60000002 (best 1.00000000), test acc: 0.80000001 (best 0.60000002)
In epoch 125, loss: 0.63348788, val acc: 0.40000001 (best 1.00000000), test acc: 0.80000001 (best 0.60000002)
In epoch 130, loss: 0.64721137, val acc: 0.60000002 (best 1.00000000), test acc: 0.80000001 (best 0.60000002)
In epoch 135, loss: 0.61149645, val acc: 0.60000002 (best 1.00000000), test acc: 0.60000002 (best 0.60000002)
In epoch 140, loss: 0.73249656, val acc: 0.80000001 (best 1.00000000), test acc: 0.80000001 (best 0.60000002)
In epoch 145, loss: 0.77375329, val acc: 1.00000000 (best 1.00000000), test acc: 0.60000002 (best 0.60000002)
In epoch 150, loss: 0.67116225, val acc: 0.60000002 (best 1.00000000), test acc: 0.40000001 (best 0.60000002)
In epoch 155, loss: 0.64774859, val acc: 0.40000001 (best 1.00000000), test acc: 0.40000001 (best 0.60000002)
In epoch 160, loss: 0.70023358, val acc: 0.20000000 (best 1.00000000), test acc: 0.60000002 (best 0.60000002)
In epoch 165, loss: 0.72687662, val acc: 0.00000000 (best 1.00000000), test acc: 0.60000002 (best 0.60000002)
In epoch 170, loss: 0.69116086, val acc: 0.60000002 (best 1.00000000), test acc: 0.20000000 (best 0.60000002)
In epoch 175, loss: 0.74121797, val acc: 0.40000001 (best 1.00000000), test acc: 0.40000001 (best 0.60000002)
In epoch 180, loss: 0.69898045, val acc: 0.80000001 (best 1.00000000), test acc: 0.60000002 (best 0.60000002)
In epoch 185, loss: 0.71680623, val acc: 0.40000001 (best 1.00000000), test acc: 0.40000001 (best 0.60000002)
In epoch 190, loss: 0.68536377, val acc: 0.40000001 (best 1.00000000), test acc: 0.40000001 (best 0.60000002)
In epoch 195, loss: 0.71111500, val acc: 0.20000000 (best 1.00000000), test acc: 0.80000001 (best 0.60000002)
In epoch 200, loss: 0.68061411, val acc: 0.60000002 (best 1.00000000), test acc: 0.40000001 (best 0.60000002)
In epoch 205, loss: 0.67588937, val acc: 0.60000002 (best 1.00000000), test acc: 0.60000002 (best 0.60000002)
In epoch 210, loss: 0.70876896, val acc: 0.60000002 (best 1.00000000), test acc: 0.20000000 (best 0.60000002)
In epoch 215, loss: 0.67690551, val acc: 0.60000002 (best 1.00000000), test acc: 0.60000002 (best 0.60000002)
In epoch 220, loss: 0.66399276, val acc: 0.40000001 (best 1.00000000), test acc: 0.20000000 (best 0.60000002)
In epoch 225, loss: 0.68663377, val acc: 0.40000001 (best 1.00000000), test acc: 0.00000000 (best 0.60000002)
In epoch 230, loss: 0.67925465, val acc: 0.40000001 (best 1.00000000), test acc: 0.80000001 (best 0.60000002)
In epoch 235, loss: 0.75748503, val acc: 0.40000001 (best 1.00000000), test acc: 0.40000001 (best 0.60000002)
In epoch 240, loss: 0.66699302, val acc: 0.80000001 (best 1.00000000), test acc: 0.80000001 (best 0.60000002)
In epoch 245, loss: 0.69626433, val acc: 0.40000001 (best 1.00000000), test acc: 0.40000001 (best 0.60000002)
In epoch 250, loss: 0.74953431, val acc: 0.80000001 (best 1.00000000), test acc: 0.60000002 (best 0.60000002)
In epoch 255, loss: 0.69572437, val acc: 0.60000002 (best 1.00000000), test acc: 0.80000001 (best 0.60000002)
In epoch 260, loss: 0.65581191, val acc: 0.60000002 (best 1.00000000), test acc: 0.20000000 (best 0.60000002)
In epoch 265, loss: 0.71385932, val acc: 0.60000002 (best 1.00000000), test acc: 0.60000002 (best 0.60000002)
In epoch 270, loss: 0.73258936, val acc: 0.60000002 (best 1.00000000), test acc: 0.20000000 (best 0.60000002)
In epoch 275, loss: 0.73522872, val acc: 0.20000000 (best 1.00000000), test acc: 0.60000002 (best 0.60000002)
In epoch 280, loss: 0.69775867, val acc: 0.80000001 (best 1.00000000), test acc: 0.60000002 (best 0.60000002)
In epoch 285, loss: 0.67734641, val acc: 0.40000001 (best 1.00000000), test acc: 0.40000001 (best 0.60000002)
In epoch 290, loss: 0.66040033, val acc: 0.80000001 (best 1.00000000), test acc: 0.40000001 (best 0.60000002)
In epoch 295, loss: 0.68019944, val acc: 0.40000001 (best 1.00000000), test acc: 0.40000001 (best 0.60000002)
In epoch 300, loss: 0.65287137, val acc: 0.40000001 (best 1.00000000), test acc: 0.40000001 (best 0.60000002)
In epoch 305, loss: 0.73355043, val acc: 0.60000002 (best 1.00000000), test acc: 0.20000000 (best 0.60000002)
In epoch 310, loss: 0.69710588, val acc: 0.40000001 (best 1.00000000), test acc: 0.60000002 (best 0.60000002)
In epoch 315, loss: 0.67291605, val acc: 0.40000001 (best 1.00000000), test acc: 0.60000002 (best 0.60000002)
In epoch 320, loss: 0.68789381, val acc: 0.60000002 (best 1.00000000), test acc: 0.60000002 (best 0.60000002)
In epoch 325, loss: 0.71691942, val acc: 0.80000001 (best 1.00000000), test acc: 0.20000000 (best 0.60000002)
In epoch 330, loss: 0.66656721, val acc: 0.40000001 (best 1.00000000), test acc: 0.40000001 (best 0.60000002)
In epoch 335, loss: 0.66030973, val acc: 0.60000002 (best 1.00000000), test acc: 0.40000001 (best 0.60000002)
In epoch 340, loss: 0.69625074, val acc: 0.60000002 (best 1.00000000), test acc: 0.20000000 (best 0.60000002)
In epoch 345, loss: 0.69005072, val acc: 0.60000002 (best 1.00000000), test acc: 0.40000001 (best 0.60000002)
In epoch 350, loss: 0.69781017, val acc: 0.20000000 (best 1.00000000), test acc: 0.40000001 (best 0.60000002)
In epoch 355, loss: 0.68023342, val acc: 0.60000002 (best 1.00000000), test acc: 0.20000000 (best 0.60000002)
In epoch 360, loss: 0.71380705, val acc: 0.20000000 (best 1.00000000), test acc: 0.40000001 (best 0.60000002)
In epoch 365, loss: 0.66957760, val acc: 0.60000002 (best 1.00000000), test acc: 0.80000001 (best 0.60000002)
In epoch 370, loss: 0.68464428, val acc: 0.40000001 (best 1.00000000), test acc: 0.80000001 (best 0.60000002)
In epoch 375, loss: 0.66630769, val acc: 0.20000000 (best 1.00000000), test acc: 0.60000002 (best 0.60000002)
In epoch 380, loss: 0.69048995, val acc: 0.40000001 (best 1.00000000), test acc: 0.60000002 (best 0.60000002)
In epoch 385, loss: 0.72937775, val acc: 0.60000002 (best 1.00000000), test acc: 0.60000002 (best 0.60000002)
In epoch 390, loss: 0.70595586, val acc: 0.40000001 (best 1.00000000), test acc: 0.80000001 (best 0.60000002)
In epoch 395, loss: 0.66758841, val acc: 0.40000001 (best 1.00000000), test acc: 0.20000000 (best 0.60000002)
In epoch 400, loss: 0.70506746, val acc: 0.80000001 (best 1.00000000), test acc: 0.20000000 (best 0.60000002)
In epoch 405, loss: 0.59176379, val acc: 0.40000001 (best 1.00000000), test acc: 0.40000001 (best 0.60000002)
In epoch 410, loss: 0.65469015, val acc: 0.60000002 (best 1.00000000), test acc: 0.20000000 (best 0.60000002)
In epoch 415, loss: 0.68703079, val acc: 0.40000001 (best 1.00000000), test acc: 0.40000001 (best 0.60000002)
In epoch 420, loss: 0.64535600, val acc: 0.40000001 (best 1.00000000), test acc: 0.40000001 (best 0.60000002)
In epoch 425, loss: 0.67316395, val acc: 0.60000002 (best 1.00000000), test acc: 0.60000002 (best 0.60000002)
In epoch 430, loss: 0.65862644, val acc: 0.40000001 (best 1.00000000), test acc: 0.40000001 (best 0.60000002)
In epoch 435, loss: 0.69233316, val acc: 0.60000002 (best 1.00000000), test acc: 0.60000002 (best 0.60000002)
In epoch 440, loss: 0.67834979, val acc: 0.40000001 (best 1.00000000), test acc: 0.60000002 (best 0.60000002)
In epoch 445, loss: 0.69678104, val acc: 0.60000002 (best 1.00000000), test acc: 0.60000002 (best 0.60000002)
In epoch 450, loss: 0.69236851, val acc: 0.20000000 (best 1.00000000), test acc: 0.40000001 (best 0.60000002)
In epoch 455, loss: 0.71883649, val acc: 0.60000002 (best 1.00000000), test acc: 0.60000002 (best 0.60000002)
In epoch 460, loss: 0.69608885, val acc: 0.40000001 (best 1.00000000), test acc: 0.20000000 (best 0.60000002)
In epoch 465, loss: 0.67582959, val acc: 0.20000000 (best 1.00000000), test acc: 0.80000001 (best 0.60000002)
In epoch 470, loss: 0.70294058, val acc: 0.80000001 (best 1.00000000), test acc: 0.40000001 (best 0.60000002)
In epoch 475, loss: 0.69846171, val acc: 0.40000001 (best 1.00000000), test acc: 0.60000002 (best 0.60000002)
In epoch 480, loss: 0.70967972, val acc: 0.80000001 (best 1.00000000), test acc: 0.60000002 (best 0.60000002)
In epoch 485, loss: 0.70049113, val acc: 0.20000000 (best 1.00000000), test acc: 0.20000000 (best 0.60000002)
In epoch 490, loss: 0.67106503, val acc: 0.60000002 (best 1.00000000), test acc: 0.40000001 (best 0.60000002)
In epoch 495, loss: 0.78342086, val acc: 0.80000001 (best 1.00000000), test acc: 0.40000001 (best 0.60000002)
In epoch 500, loss: 0.60414940, val acc: 0.40000001 (best 1.00000000), test acc: 0.20000000 (best 0.60000002)
In epoch 505, loss: 0.66642010, val acc: 0.60000002 (best 1.00000000), test acc: 0.60000002 (best 0.60000002)
In epoch 510, loss: 0.66728258, val acc: 0.20000000 (best 1.00000000), test acc: 0.40000001 (best 0.60000002)
In epoch 515, loss: 0.70236510, val acc: 0.40000001 (best 1.00000000), test acc: 0.60000002 (best 0.60000002)
In epoch 520, loss: 0.66535538, val acc: 0.60000002 (best 1.00000000), test acc: 0.40000001 (best 0.60000002)
In epoch 525, loss: 0.69165599, val acc: 0.80000001 (best 1.00000000), test acc: 0.60000002 (best 0.60000002)
In epoch 530, loss: 0.69069105, val acc: 0.20000000 (best 1.00000000), test acc: 0.60000002 (best 0.60000002)
In epoch 535, loss: 0.67577285, val acc: 0.40000001 (best 1.00000000), test acc: 0.40000001 (best 0.60000002)
In epoch 540, loss: 0.68727815, val acc: 0.40000001 (best 1.00000000), test acc: 0.80000001 (best 0.60000002)
In epoch 545, loss: 0.71458060, val acc: 0.20000000 (best 1.00000000), test acc: 0.20000000 (best 0.60000002)
In epoch 550, loss: 0.69320786, val acc: 0.80000001 (best 1.00000000), test acc: 0.40000001 (best 0.60000002)
In epoch 555, loss: 0.72181571, val acc: 0.80000001 (best 1.00000000), test acc: 0.00000000 (best 0.60000002)
In epoch 560, loss: 0.67493677, val acc: 0.80000001 (best 1.00000000), test acc: 0.20000000 (best 0.60000002)
In epoch 565, loss: 0.69515687, val acc: 0.40000001 (best 1.00000000), test acc: 0.60000002 (best 0.60000002)
In epoch 570, loss: 0.74017185, val acc: 0.40000001 (best 1.00000000), test acc: 0.40000001 (best 0.60000002)
In epoch 575, loss: 0.65468597, val acc: 0.80000001 (best 1.00000000), test acc: 0.20000000 (best 0.60000002)
In epoch 580, loss: 0.65377319, val acc: 1.00000000 (best 1.00000000), test acc: 0.60000002 (best 0.60000002)
In epoch 585, loss: 0.70424205, val acc: 0.80000001 (best 1.00000000), test acc: 0.80000001 (best 0.60000002)
In epoch 590, loss: 0.73723471, val acc: 0.60000002 (best 1.00000000), test acc: 0.60000002 (best 0.60000002)
In epoch 595, loss: 0.69356763, val acc: 0.60000002 (best 1.00000000), test acc: 0.40000001 (best 0.60000002)
In epoch 600, loss: 0.69023031, val acc: 0.60000002 (best 1.00000000), test acc: 0.60000002 (best 0.60000002)
```

```
In epoch 605, loss: 0.71804667, val acc: 0.40000001 (best 1.00000000), test acc: 0.60000002 (best 0.60000002)
In epoch 610, loss: 0.65557688, val acc: 0.80000001 (best 1.00000000), test acc: 0.20000000 (best 0.60000002)
In epoch 615, loss: 0.65636319, val acc: 0.60000002 (best 1.00000000), test acc: 0.80000001 (best 0.60000002)
In epoch 620, loss: 0.64237678, val acc: 0.20000000 (best 1.00000000), test acc: 0.20000000 (best 0.60000002)
In epoch 625, loss: 0.69880027, val acc: 0.40000001 (best 1.00000000), test acc: 1.00000000 (best 0.60000002)
In epoch 630, loss: 0.66862571, val acc: 0.40000001 (best 1.00000000), test acc: 0.60000002 (best 0.60000002)
In epoch 635, loss: 0.71697938, val acc: 0.20000000 (best 1.00000000), test acc: 0.20000000 (best 0.60000002)
In epoch 640, loss: 0.69136047, val acc: 0.40000001 (best 1.00000000), test acc: 0.60000002 (best 0.60000002)
In epoch 645, loss: 0.70799369, val acc: 0.60000002 (best 1.00000000), test acc: 0.00000000 (best 0.60000002)
In epoch 650, loss: 0.66819632, val acc: 0.80000001 (best 1.00000000), test acc: 0.60000002 (best 0.60000002)
In epoch 655, loss: 0.62669951, val acc: 0.80000001 (best 1.00000000), test acc: 0.60000002 (best 0.60000002)
In epoch 660, loss: 0.71225512, val acc: 0.60000002 (best 1.00000000), test acc: 0.20000000 (best 0.60000002)
In epoch 665, loss: 0.71507406, val acc: 0.80000001 (best 1.00000000), test acc: 0.60000002 (best 0.60000002)
In epoch 670, loss: 0.68541181, val acc: 0.80000001 (best 1.00000000), test acc: 0.60000002 (best 0.60000002)
In epoch 675, loss: 0.69149733, val acc: 0.60000002 (best 1.00000000), test acc: 0.20000000 (best 0.60000002)
In epoch 680, loss: 0.73088843, val acc: 0.20000000 (best 1.00000000), test acc: 0.40000001 (best 0.60000002)
In epoch 685, loss: 0.70393020, val acc: 0.40000001 (best 1.00000000), test acc: 0.60000002 (best 0.60000002)
In epoch 690, loss: 0.69476098, val acc: 0.20000000 (best 1.00000000), test acc: 0.60000002 (best 0.60000002)
In epoch 695, loss: 0.68425953, val acc: 0.80000001 (best 1.00000000), test acc: 0.60000002 (best 0.60000002)
```

In [33]:
```python
plt.plot(graph_classif_losses, 'r-')
plt.title('Training Loss')
plt.xlabel('Iterations')
plt.ylabel('Loss')
plt.show()
```

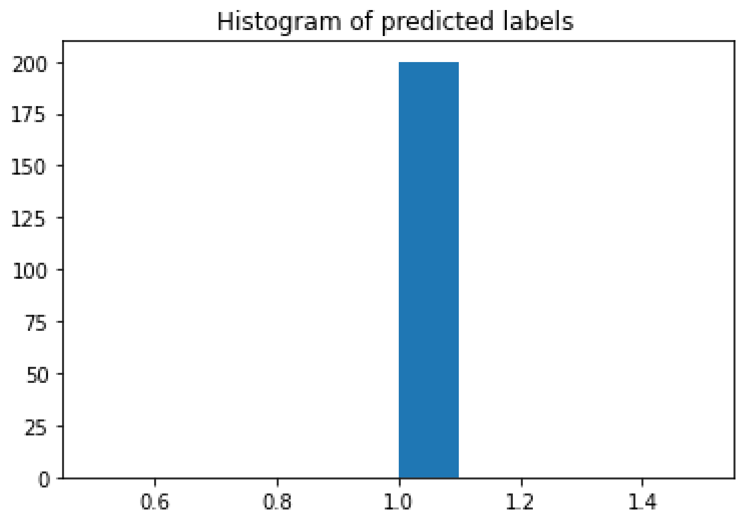


In [36]:
```python
plt.figure(figsize=(15, 5))
plt.plot(graph_classif_accs['train'], 'r-', label='Training Accuracy')
plt.plot(graph_classif_accs['val'], 'g-', label='Val Accuracy')
plt.plot(graph_classif_accs['test'], 'b-', label='Test Accuracy')
plt.title('Accuracies')
plt.xlabel('Iterations')
plt.ylabel('Accuracy')
plt.legend()
plt.show()
```

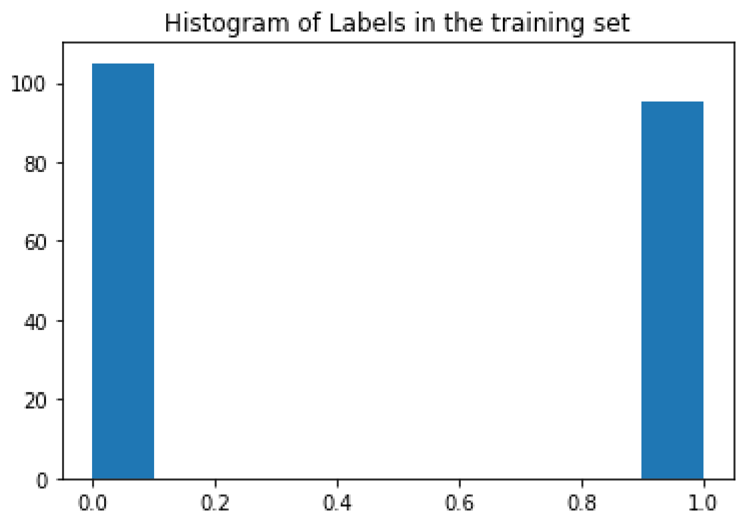


In [29]:
```python
all_preds_graph_classif = []
for batched_graph_test, labels_test in test_dataloader:
    batched_graph_test = batched_graph_test.to('cuda')
    labels_test = labels_test.to('cuda')
    logits_test = graph_classif_model(batched_graph_test, batched_graph_test.ndata['feat'].float())
    pred_test = logits_test.argmax(1)
    all_preds_graph_classif = all_preds_graph_classif + [*pred_test.cpu().numpy()]
```

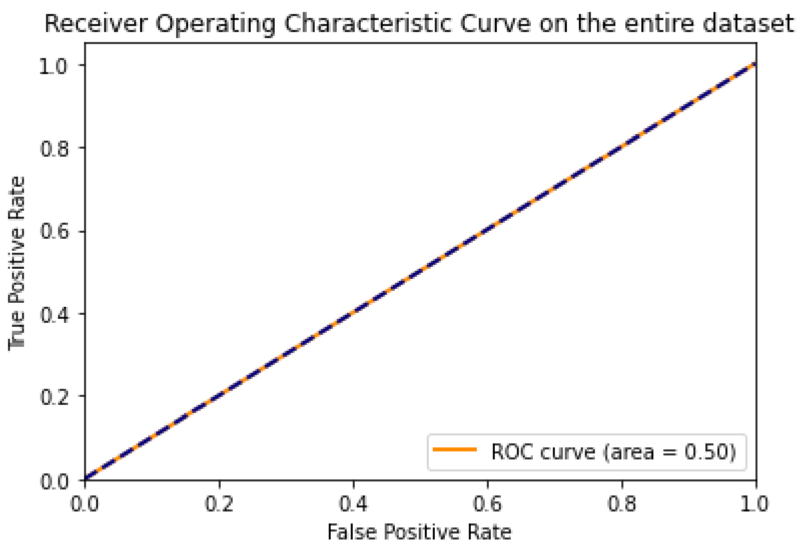
In [35]:
```python
plt.hist(all_preds_graph_classif)
plt.title("Histogram of predicted labels ")
plt.show()
```



In [34]:
```
label = graph_classif_dataset.labels[graph_classif_dataset.test_mask]
plt.hist(label.cpu().numpy())
plt.title("Histogram of Labels in the training set")
plt.show()
```



In [32]:
```
from sklearn.metrics import auc, roc_curve
fpr, tpr, _ = roc_curve(label.cpu().numpy(), all_preds_graph_classif)
roc_auc = auc(fpr, tpr)
plt.figure()
lw = 2
plt.plot(fpr, tpr, color='darkorange',
lw=lw, label='ROC curve (area = %0.2f)' % roc_auc)
plt.plot([0, 1], [0, 1], color='navy', lw=lw, linestyle='--')
plt.xlim([0.0, 1.0])
plt.ylim([0.0, 1.05])
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('Receiver Operating Characteristic Curve on the entire dataset')
plt.legend(loc="lower right")
plt.show()
```



Comparison

As we can see above, theoritically both the architectures will work. The loss vs iteration curve and the ROC suggest that the graph classification approcach has failed to learn and it is preidicting the same output for all inputs. The main reason for this result is that:

1. I used very less training data
2. The training data has very less number of features.
3. The limited computational resource. The colab notebook's RAM was getting used up even before training for 1000 epochs. As we can see in the Node Classification approach, the GNN required atleast a 1000 epochs to stabilize.

Because of the above reasons, I think the Graph Classification approach gave inferior performance.

Possible Improvements

- Neural Message Passing Models have shown good results on other particle jet classification tasks like here.
- Studying and applying better ways of encoding the train data in the form of graphs