Lab 3: Gesture Recognition using Convolutional Neural Networks

In this lab you will train a convolutional neural network to make classifications on different hand gestures. By the end of the lab, you should be able to:

1. Load and split data for training, validation and testing
2. Train a Convolutional Neural Network
3. Apply transfer learning to improve your model

Note that for this lab we will not be providing you with any starter code. You should be able to take the code used in previous labs, tutorials and lectures and modify it accordingly to complete the tasks outlined below.

What to submit

Submit a PDF file containing all your code, outputs, and write-up from parts 1-5. You can produce a PDF of your Google Colab file by going to **File > Print** and then save as PDF. The Colab instructions has more information. Make sure to review the PDF submission to ensure that your answers are easy to read. Make sure that your text is not cut off at the margins.

Do not submit any other files produced by your code.

Include a link to your colab file in your submission.

Please use Google Colab to complete this assignment. If you want to use Jupyter Notebook, please complete the assignment and upload your Jupyter Notebook file to Google Colab for submission.

Colab Link

Include a link to your colab file here

Colab Link: https://drive.google.com/file/d/1cSqgUgLq9IfT58IWZAmHgUsoKp5NqTKu/view?usp=sharing (https://drive.google.com/file/d/1cSqgUgLq9IfT58IWZAmHgUsoKp5NqTKu/view?usp=sharing)

Dataset

American Sign Language (ASL) is a complete, complex language that employs signs made by moving the hands combined with facial expressions and postures of the body. It is the primary language of many North Americans who are deaf and is one of several communication options used by people who are deaf or hard-of-hearing. The hand gestures representing English alphabet are shown below. This lab focuses on classifying a subset of these hand gesture images using convolutional neural networks. Specifically, given an image of a hand showing one of the letters A-I, we want to detect which letter is being represented.

Part B. Building a CNN [50 pt]

For this lab, we are not going to give you any starter code. You will be writing a convolutional neural network from scratch. You are welcome to use any code from previous labs, lectures and tutorials. You should also write your own code.

You may use the PyTorch documentation freely. You might also find online tutorials helpful. However, all code that you submit must be your own.

Make sure that your code is vectorized, and does not contain obvious inefficiencies (for example, unecessary for loops, or unnecessary calls to unsqueeze()). Ensure enough comments are included in the code so that your TA can understand what you are doing. It is your responsibility to show that you understand what you write.

This is much more challenging and time-consuming than the previous labs. Make sure that you give yourself plenty of time by starting early.

1. Data Loading and Splitting [5 pt]

Download the anonymized data provided on Quercus. To allow you to get a heads start on this project we will provide you with sample data from previous years. Split the data into training, validation, and test sets.

Note: Data splitting is not as trivial in this lab. We want our test set to closely resemble the setting in which our model will be used. In particular, our test set should contain hands that are never seen in training!

Explain how you split the data, either by describing what you did, or by showing the code that you used. Justify your choice of splitting strategy. How many training, validation, and test images do you have?

For loading the data, you can use plt.imread as in Lab 1, or any other method that you choose. You may find torchvision.datasets.ImageFolder helpful. (see https://pytorch.org/docs/stable/torchvision/datasets.html?highlight=image%20folder#torchvision.datasets.ImageFolder (https://pytorch.org/docs/stable/torchvision/datasets.html?highlight=image%20folder#torchvision.datasets.ImageFolder))

In [2]:
```
# Setup
import numpy as np
import matplotlib.pyplot as plt
import os
import cv2

import torch
import torch.nn as nn
import torch.nn.functional as F
import torchvision
import torch.optim as optim
from torch.utils.data import DataLoader

from google.colab import drive
drive.mount('/content/drive')
lab_path = './drive/MyDrive/Lab3_Dataset/Lab3_Gestures_Summer'

use_cuda = torch.cuda.is_available()
device = torch.device("cuda:0" if use_cuda else "cpu")
torch.backends.cudnn.benchmark = True

idx_to_alpha = {'0': 'A', '1': 'B', '2': 'C', '3': 'D', '4': 'E',
                '5': 'F', '6': 'G', '7': 'H', '8': 'I'}
alpha_to_idx = {'A': 0, 'B': 1, 'C': 2, 'D': 3, 'E': 4, 'F': 5,
                'G': 6, 'H': 7, 'I': 8}
```

```
Drive already mounted at /content/drive; to attempt to forcibly remount, call
drive.mount("/content/drive", force_remount=True).
```

In [3]:
```
# Dataset class
class Dataset(torch.utils.data.Dataset):
  def __init__(self, photos, labels):
    self.photos = photos
    self.labels = labels

  def __len__(self):
    return len(self.photos)

  def __getitem__(self, idx):
    photo = self.photos[idx]
    label = self.labels[idx]

    return photo, label
```

In [4]:
```
def data_prep(data_path, p):
  ########## Load Data ##########
  # Load paths of all images into a 2D list (photos[letter][photo])

  # Load letter file names
  letters = os.listdir(data_path)
  letters = sorted(letters)

  # Iterate through photos and append path of each
  photos = []
  least_photos = 9999999
  for i in letters:
    temp_paths = []
    files = os.listdir(data_path + '/' + i)

    for j in files:
      temp_paths.append(data_path + '/' + i + "/" + j)

    photos.append(temp_paths)

    if len(files) < least_photos:
      least_photos = len(files)

  ########## Split Data / Create Datasets ##########
  # Split into training, validation, testing 2D lists
  num_val_test = int(p * least_photos) # least number of photos for a letter
  # Want to have an equal number of letters in testing and validation data

  training_data, training_labels = [], []
  validation_data, validation_labels = [], []
  testing_data, testing_labels = [], []

  for i in range(len(photos)): # loop through each letter
    # Split data (splitting before shuffling to ensure
    # validation and testing sets have unseen hands/environments)
    validation_data = validation_data + (photos[i][0:num_val_test])
    testing_data = testing_data + (photos[i][num_val_test:2*num_val_test])
    training_data = training_data + (photos[i][2*num_val_test:])

    # Add appropriate labels
    validation_labels = validation_labels + ([i] * num_val_test)
    testing_labels = testing_labels + ([i] * num_val_test)
    training_labels = training_labels + ([i] * len(photos[i][2*num_val_tes
t:]))

  # Turn into image data
  for i in range(len(validation_data)):
    validation_data[i] = cv2.imread(validation_data[i])
  for i in range(len(testing_data)):
    testing_data[i] = cv2.imread(testing_data[i])
  for i in range(len(training_data)):
    training_data[i] = cv2.imread(training_data[i])

  # Save processed data
  np.save("validation_data.npy", np.array(validation_data, dtype=np.float32))
  np.save("testing_data.npy", np.array(testing_data, dtype=np.float32))
```

```
  np.save("training_data.npy", np.array(training_data, dtype=np.float32))

  np.save("validation_labels.npy", validation_labels)
  np.save("testing_labels.npy", testing_labels)
  np.save("training_labels.npy", training_labels)


def create_sets(train_path, val_path, test_path):
  # Loading processed data
  training_data = np.moveaxis(np.load(train_path + "/training_data.npy"), -1,
1)
  training_labels = np.load(train_path + "/training_labels.npy")

  validation_data = np.moveaxis(np.load(val_path + "/validation_data.npy"), -
1, 1)
  validation_labels = np.load(val_path + "/validation_labels.npy")

  testing_data = np.moveaxis(np.load(test_path + "/testing_data.npy"), -1, 1)
  testing_labels = np.load(test_path + "/testing_labels.npy")

  # Create datasets
  training_set = Dataset(training_data, training_labels)
  validation_set = Dataset(validation_data, validation_labels)
  testing_set = Dataset(testing_data, testing_labels)

  return (training_set, validation_set, testing_set)
```

Data splitting considerations

- Want to have unseen hands in validation and test datasets
- Want to have an equal number of each sign in the validation/test set to get unbiased measurement of accuracy

Data splitting strategy

1. Find the folder with the least number of photos
2. Take 10% (of least number) for validation, 10% for testing, the rest for training (before shuffling since the photos are paired)

Also want to save the processed data so that I don't need to reprocess all the data every time.

2. Model Building and Sanity Checking [15 pt]

Part (a) Convolutional Network - 5 pt

Build a convolutional neural network model that takes the (224x224 RGB) image as input, and predicts the gesture letter. Your model should be a subclass of nn.Module. Explain your choice of neural network architecture: how many layers did you choose? What types of layers did you use? Were they fully-connected or convolutional? What about other decisions like pooling layers, activation functions, number of channels / hidden units?

In [5]:
```
class CNN(nn.Module):
  def __init__(self):
    super(CNN, self).__init__()
    self.conv1 = nn.Conv2d(3, 5, 5) # in_channels, out_channels, kernel_size
    self.pool = nn.MaxPool2d(2, 2) # kernel_size, stride
    self.conv2 = nn.Conv2d(5, 10, 5)

    self.fc1 = nn.Linear(10*53*53, 25)
    self.fc2 = nn.Linear(25, 9)

  def forward(self, x):
    # Convolutional layer 1
    x = self.conv1(x)
    x = F.relu(x)
    x = self.pool(x)

    # Convolutional layer 2
    x = self.conv2(x)
    x = F.relu(x)
    x = self.pool(x)

    # Classification layer
    x = x.view(-1, 10*53*53)
    x = F.relu(self.fc1(x))
    x = self.fc2(x)
    return x
```

I chose to use 2 convolutional layers followed by 2 fully-connected layers for the classifier. I followed the general CNN architecture and I determined the number of layers and such based on how well my model performed. I found that using 2 CNN layers, my model was able to capture the trends in the data so I didn't want to add anymore, which would have increased computational cost. I also chose to use 2 layers for the classification network because 2 layers should be enough to classify most things and the model was already overfitting.

I used pooling layers in every convolutional layer with a kernel size of 2 and a stride of 2 to capture the entire layer with minimum overlap to reduce extra computation.

I used ReLU activation function since ReLU generally works better than activation functions like sigmoid. A softmax activation was used for the last layer since this was a classification task (included in the loss function).

The number of channels and hidden units were chosen by looking at trends in overfitting/underfitting when tuning the hyperparameters of the model. When the model overfit, I reduced the number of channels and hidden units to reduce the capacity of the model.

Part (b) Training Code - 5 pt

Write code that trains your neural network given some training data. Your training code should make it easy to tweak the usual hyperparameters, like batch size, learning rate, and the model object itself. Make sure that you are checkpointing your models from time to time (the frequency is up to you). Explain your choice of loss function and optimizer.

In [6]:
```
def calc_acc(model, loader):
  correct = 0
  total = 0
  n = 0
  for img, label in loader:
    # Move to GPU
    img, label = img.to(device), label.to(device)

    # Make prediction
    out = model(img)

    # Select index with max prediction score
    pred = out.max(1, keepdim=True)[1]
    correct += pred.eq(label.view_as(pred)).sum().item()
    total += img.shape[0]
    n += 1

  return correct/total
```

In [7]:
```
def plot_train(iter, loss, train_acc, val_acc):
  plt.title("Training Curve")
  plt.plot(iter, loss, label="Train")
  plt.xlabel("Iterations")
  plt.ylabel("Loss")
  plt.show()

  plt.title("Training Curve")
  plt.plot(iter, train_acc, label="Train")
  plt.plot(iter, val_acc, label="Validation")
  plt.xlabel("Iterations")
  plt.ylabel("Accuracy")
  plt.legend(loc='best')
  plt.show()

  print(f"Final training accuracy: {train_acc[-1]}")
  print(f"Final validation accuracy: {val_acc[-1]}")
```

In [8]:
```
def train(model, training_set, validation_set, num_epochs=1, lr=0.001, batch_s
ize=64):
  # Create Dataloaders
  params = {
      'batch_size': batch_size,
      'shuffle': True
  }

  training_loader = DataLoader(training_set, **params)
  validation_loader = DataLoader(validation_set, **params)

  # Setup
  criterion = nn.CrossEntropyLoss()
  optimizer = optim.Adam(model.parameters(), lr=lr)

  n, iter, losses, train_acc, val_acc = 0, [], [], [], []

  transform = torchvision.transforms.ToPILImage()

  # Training
  for epoch in range(num_epochs):
    for img, label in training_loader:
      # Move to GPU
      img, label = img.to(device), label.to(device)

      # Forward pass
      out = model(img)

      # Compute loss
      loss = criterion(out, label)

      # Backward Pass
      loss.backward()
      optimizer.step()
      optimizer.zero_grad()

      # Save current training info
      iter.append(n)
      losses.append(float(loss)/img.shape[0])

      train_acc_temp = calc_acc(model, training_loader)
      val_acc_temp = calc_acc(model, validation_loader)
      train_acc.append(train_acc_temp)
      val_acc.append(val_acc_temp)

      print(f"Iteration {n}, epoch {epoch+1}")
      print(f"Loss {float(loss)/img.shape[0]}, train accuracy {train_acc_tem
p}, val accuracy {val_acc_temp}")

      n += 1

    torch.save(model.state_dict(), f"CNN_epoch_{epoch}")

  # Plot training curves
  plot_train(iter, losses, train_acc, val_acc)
```

I chose CrossEntropyLoss as the loss function because this is a classification task where cross entropy generally works better than loss functions like MSE that are more suited for regression. The CrossEntropyLoss function also has a built in sigmoid function so it doesn't need to be included in my network.

I chose Adam as the optimizer since Adam will generally work well with most networks and it combines momentum functions with RMSprop algorithms.

Part (c) “Overfit” to a Small Dataset - 5 pt

One way to sanity check our neural network model and training code is to check whether the model is capable of “overfitting” or “memorizing” a small dataset. A properly constructed CNN with correct training code should be able to memorize the answers to a small number of images quickly.

Construct a small dataset (e.g. just the images that you have collected). Then show that your model and training code is capable of memorizing the labels of this small data set.

With a large batch size (e.g. the entire small dataset) and learning rate that is not too high, You should be able to obtain a 100% training accuracy on that small dataset relatively quickly (within 200 iterations).

In [29]:
```
# Prepare data
data_prep("./drive/MyDrive/Lab3_Dataset/miniset", 0.3) # 45 images of each let
ter
```

In [31]:
```
# Load data
training_sets, validation_sets, testing_sets = create_sets(
    ".", ".", ".")

# Initialize model
model_CNN = CNN()
model_CNN.to(device)

# Train model
train(model_CNN, training_sets, validation_sets, num_epochs=10, batch_size=5)
```

```
Iteration 0, epoch 1
Loss 3.0353414535522463, train accuracy 0.1111111111111111, val accuracy 0.11
11111111111111
Iteration 1, epoch 1
Loss 23.927548217773438, train accuracy 0.1111111111111111, val accuracy 0.11
11111111111111
Iteration 2, epoch 1
Loss 13.923530578613281, train accuracy 0.1111111111111111, val accuracy 0.11
11111111111111
Iteration 3, epoch 1
Loss 21.064450073242188, train accuracy 0.1111111111111111, val accuracy 0.11
11111111111111
Iteration 4, epoch 1
Loss 9.129312896728516, train accuracy 0.1111111111111111, val accuracy 0.094
01709401709402
Iteration 5, epoch 1
Loss 2.6323455810546874, train accuracy 0.1111111111111111, val accuracy 0.11
11111111111111
Iteration 6, epoch 1
Loss 2.31528377532959, train accuracy 0.1111111111111111, val accuracy 0.1111
111111111111
Iteration 7, epoch 1
Loss 1.8197303771972657, train accuracy 0.18128654970760233, val accuracy 0.1
3675213675213677
Iteration 8, epoch 1
Loss 0.40634660720825194, train accuracy 0.18128654970760233, val accuracy 0.
1282051282051282
Iteration 9, epoch 1
Loss 0.46067109107971194, train accuracy 0.15789473684210525, val accuracy 0.
1623931623931624
Iteration 10, epoch 1
Loss 0.4260819911956787, train accuracy 0.1695906432748538, val accuracy 0.16
23931623931624
Iteration 11, epoch 1
Loss 0.5079712867736816, train accuracy 0.1871345029239766, val accuracy 0.16
23931623931624
Iteration 12, epoch 1
Loss 0.42448854446411133, train accuracy 0.19883040935672514, val accuracy 0.
13675213675213677
Iteration 13, epoch 1
Loss 0.4139249801635742, train accuracy 0.19298245614035087, val accuracy 0.1
282051282051282
Iteration 14, epoch 1
Loss 0.45339136123657225, train accuracy 0.19883040935672514, val accuracy 0.
11965811965811966
Iteration 15, epoch 1
Loss 0.44550375938415526, train accuracy 0.17543859649122806, val accuracy 0.
1111111111111111
Iteration 16, epoch 1
Loss 0.44873342514038084, train accuracy 0.1871345029239766, val accuracy 0.1
452991452991453
Iteration 17, epoch 1
Loss 0.4461184024810791, train accuracy 0.1871345029239766, val accuracy 0.13
675213675213677
Iteration 18, epoch 1
Loss 0.44026803970336914, train accuracy 0.18128654970760233, val accuracy 0.
1452991452991453
```

```
Iteration 19, epoch 1
Loss 0.46132445335388184, train accuracy 0.18128654970760233, val accuracy 0.
13675213675213677
Iteration 20, epoch 1
Loss 0.46353864669799805, train accuracy 0.18128654970760233, val accuracy 0.
1282051282051282
Iteration 21, epoch 1
Loss 0.45052213668823243, train accuracy 0.1871345029239766, val accuracy 0.1
282051282051282
Iteration 22, epoch 1
Loss 0.4409933567047119, train accuracy 0.19883040935672514, val accuracy 0.1
282051282051282
Iteration 23, epoch 1
Loss 0.4424149513244629, train accuracy 0.19883040935672514, val accuracy 0.1
282051282051282
Iteration 24, epoch 1
Loss 0.43230476379394533, train accuracy 0.21052631578947367, val accuracy 0.
11965811965811966
Iteration 25, epoch 1
Loss 0.4078559398651123, train accuracy 0.21637426900584794, val accuracy 0.1
282051282051282
Iteration 26, epoch 1
Loss 0.46456308364868165, train accuracy 0.21052631578947367, val accuracy 0.
1282051282051282
Iteration 27, epoch 1
Loss 0.42262701988220214, train accuracy 0.21052631578947367, val accuracy 0.
1282051282051282
Iteration 28, epoch 1
Loss 0.44328832626342773, train accuracy 0.2046783625730994, val accuracy 0.1
3675213675213677
Iteration 29, epoch 1
Loss 0.43979129791259763, train accuracy 0.2046783625730994, val accuracy 0.1
3675213675213677
Iteration 30, epoch 1
Loss 0.42379207611083985, train accuracy 0.21052631578947367, val accuracy 0.
1282051282051282
Iteration 31, epoch 1
Loss 0.4506053447723389, train accuracy 0.21052631578947367, val accuracy 0.1
282051282051282
Iteration 32, epoch 1
Loss 0.46497745513916017, train accuracy 0.22807017543859648, val accuracy 0.
1282051282051282
Iteration 33, epoch 1
Loss 0.4578404426574707, train accuracy 0.22807017543859648, val accuracy 0.1
282051282051282
Iteration 34, epoch 1
Loss 2.4728856086730957, train accuracy 0.22807017543859648, val accuracy 0.1
3675213675213677
Iteration 35, epoch 2
Loss 0.383845853805542, train accuracy 0.2222222222222222, val accuracy 0.136
75213675213677
Iteration 36, epoch 2
Loss 0.4388468265533447, train accuracy 0.2222222222222222, val accuracy 0.12
82051282051282
Iteration 37, epoch 2
Loss 0.4342545509338379, train accuracy 0.21637426900584794, val accuracy 0.1
1965811965811966
```

```
Iteration 38, epoch 2
Loss 0.41306381225585936, train accuracy 0.22807017543859648, val accuracy 0.
11965811965811966
Iteration 39, epoch 2
Loss 0.40682644844055177, train accuracy 0.2222222222222222, val accuracy 0.1
1965811965811966
Iteration 40, epoch 2
Loss 0.3943317413330078, train accuracy 0.23391812865497075, val accuracy 0.1
1965811965811966
Iteration 41, epoch 2
Loss 0.44775190353393557, train accuracy 0.23391812865497075, val accuracy 0.
13675213675213677
Iteration 42, epoch 2
Loss 0.3581089019775391, train accuracy 0.2046783625730994, val accuracy 0.12
82051282051282
Iteration 43, epoch 2
Loss 0.3730325698852539, train accuracy 0.2222222222222222, val accuracy 0.12
82051282051282
Iteration 44, epoch 2
Loss 0.4225192070007324, train accuracy 0.2222222222222222, val accuracy 0.12
82051282051282
Iteration 45, epoch 2
Loss 0.39530510902404786, train accuracy 0.21637426900584794, val accuracy 0.
1452991452991453
Iteration 46, epoch 2
Loss 0.35317378044128417, train accuracy 0.22807017543859648, val accuracy 0.
13675213675213677
Iteration 47, epoch 2
Loss 0.35306649208068847, train accuracy 0.26900584795321636, val accuracy 0.
13675213675213677
Iteration 48, epoch 2
Loss 0.3309581756591797, train accuracy 0.27485380116959063, val accuracy 0.1
623931623931624
Iteration 49, epoch 2
Loss 0.39783873558044436, train accuracy 0.19298245614035087, val accuracy 0.
17094017094017094
Iteration 50, epoch 2
Loss 0.9079368591308594, train accuracy 0.2982456140350877, val accuracy 0.16
23931623931624
Iteration 51, epoch 2
Loss 0.48923187255859374, train accuracy 0.2982456140350877, val accuracy 0.1
8803418803418803
Iteration 52, epoch 2
Loss 0.4285830020904541, train accuracy 0.30994152046783624, val accuracy 0.1
7948717948717795
Iteration 53, epoch 2
Loss 0.4075010299682617, train accuracy 0.2982456140350877, val accuracy 0.16
23931623931624
Iteration 54, epoch 2
Loss 0.4336073875427246, train accuracy 0.28654970760233917, val accuracy 0.1
5384615384615385
Iteration 55, epoch 2
Loss 0.3906108379364014, train accuracy 0.28654970760233917, val accuracy 0.1
623931623931624
Iteration 56, epoch 2
Loss 0.4223358154296875, train accuracy 0.28654970760233917, val accuracy 0.1
5384615384615385
```

```
Iteration 57, epoch 2
Loss 0.3675595045089722, train accuracy 0.27485380116959063, val accuracy 0.1
7094017094017094
Iteration 58, epoch 2
Loss 0.42827520370483396, train accuracy 0.27485380116959063, val accuracy 0.
1623931623931624
Iteration 59, epoch 2
Loss 0.36391472816467285, train accuracy 0.27485380116959063, val accuracy 0.
15384615384615385
Iteration 60, epoch 2
Loss 0.3738752841949463, train accuracy 0.27485380116959063, val accuracy 0.1
452991452991453
Iteration 61, epoch 2
Loss 0.425687313079834, train accuracy 0.27485380116959063, val accuracy 0.14
52991452991453
Iteration 62, epoch 2
Loss 0.3474102020263672, train accuracy 0.28654970760233917, val accuracy 0.1
452991452991453
Iteration 63, epoch 2
Loss 0.42939014434814454, train accuracy 0.28654970760233917, val accuracy 0.
15384615384615385
Iteration 64, epoch 2
Loss 0.33612675666809083, train accuracy 0.29239766081871343, val accuracy 0.
17094017094017094
Iteration 65, epoch 2
Loss 0.41831421852111816, train accuracy 0.28654970760233917, val accuracy 0.
17094017094017094
Iteration 66, epoch 2
Loss 0.38397784233093263, train accuracy 0.2982456140350877, val accuracy 0.1
794871794871795
Iteration 67, epoch 2
Loss 0.45465970039367676, train accuracy 0.2982456140350877, val accuracy 0.1
794871794871795
Iteration 68, epoch 2
Loss 0.41683435440063477, train accuracy 0.30409356725146197, val accuracy 0.
1794871794871795
Iteration 69, epoch 2
Loss 2.2511420249938965, train accuracy 0.3157894736842105, val accuracy 0.18
803418803418803
Iteration 70, epoch 3
Loss 0.42689085006713867, train accuracy 0.3333333333333333, val accuracy 0.1
9658119658119658
Iteration 71, epoch 3
Loss 0.3479130268096924, train accuracy 0.32748538011695905, val accuracy 0.1
8803418803418803
Iteration 72, epoch 3
Loss 0.3977628231048584, train accuracy 0.3333333333333333, val accuracy 0.19
658119658119658
Iteration 73, epoch 3
Loss 0.37287535667419436, train accuracy 0.3508771929824561, val accuracy 0.1
8803418803418803
Iteration 74, epoch 3
Loss 0.39089820384979246, train accuracy 0.34502923976608185, val accuracy 0.
1794871794871795
Iteration 75, epoch 3
Loss 0.2524422168731689, train accuracy 0.36257309941520466, val accuracy 0.1
794871794871795
```

```
Iteration 76, epoch 3
Loss 0.38977081775665284, train accuracy 0.3742690058479532, val accuracy 0.1
7948717948717795
Iteration 77, epoch 3
Loss 0.2519958972930908, train accuracy 0.391812865497076, val accuracy 0.188
03418803418803
Iteration 78, epoch 3
Loss 0.4254137516021729, train accuracy 0.39766081871345027, val accuracy 0.2
1367521367521367
Iteration 79, epoch 3
Loss 0.3953582286834717, train accuracy 0.40350877192982454, val accuracy 0.2
0512820512820512
Iteration 80, epoch 3
Loss 0.3215934276580811, train accuracy 0.40350877192982454, val accuracy 0.2
0512820512820512
Iteration 81, epoch 3
Loss 0.3006376981735229, train accuracy 0.4152046783625731, val accuracy 0.19
658119658119658
Iteration 82, epoch 3
Loss 0.2354489803314209, train accuracy 0.4327485380116959, val accuracy 0.19
658119658119658
Iteration 83, epoch 3
Loss 0.23930470943450927, train accuracy 0.45614035087719296, val accuracy 0.
17094017094017094
Iteration 84, epoch 3
Loss 0.42484474182128906, train accuracy 0.4619883040935672, val accuracy 0.1
7948717948717795
Iteration 85, epoch 3
Loss 0.3165611743927002, train accuracy 0.4619883040935672, val accuracy 0.18
803418803418803
Iteration 86, epoch 3
Loss 0.3028090953826904, train accuracy 0.43859649122807015, val accuracy 0.1
9658119658119658
Iteration 87, epoch 3
Loss 0.43602662086486815, train accuracy 0.4327485380116959, val accuracy 0.1
9658119658119658
Iteration 88, epoch 3
Loss 0.3372918367385864, train accuracy 0.4152046783625731, val accuracy 0.18
803418803418803
Iteration 89, epoch 3
Loss 0.23714034557342528, train accuracy 0.4093567251461988, val accuracy 0.1
8803418803418803
Iteration 90, epoch 3
Loss 0.36690306663513184, train accuracy 0.4269005847953216, val accuracy 0.1
7948717948717795
Iteration 91, epoch 3
Loss 0.42334494590759275, train accuracy 0.4853801169590643, val accuracy 0.1
8803418803418803
Iteration 92, epoch 3
Loss 0.24614403247833253, train accuracy 0.5146198830409356, val accuracy 0.2
0512820512820512
Iteration 93, epoch 3
Loss 0.581557321548462, train accuracy 0.5380116959064327, val accuracy 0.205
12820512820512
Iteration 94, epoch 3
Loss 0.32176315784454346, train accuracy 0.5730994152046783, val accuracy 0.2
3076923076923078
```

```
Iteration 95, epoch 3
Loss 0.506844425201416, train accuracy 0.5789473684210527, val accuracy 0.239
31623931623933
Iteration 96, epoch 3
Loss 0.30745954513549806, train accuracy 0.6081871345029239, val accuracy 0.2
3076923076923078
Iteration 97, epoch 3
Loss 0.2479337215423584, train accuracy 0.6081871345029239, val accuracy 0.22
22222222222222
Iteration 98, epoch 3
Loss 0.2735306978225708, train accuracy 0.6198830409356725, val accuracy 0.20
512820512820512
Iteration 99, epoch 3
Loss 0.09976394772529602, train accuracy 0.6374269005847953, val accuracy 0.2
1367521367521367
Iteration 100, epoch 3
Loss 0.4215985298156738, train accuracy 0.6432748538011696, val accuracy 0.21
367521367521367
Iteration 101, epoch 3
Loss 0.38660392761230467, train accuracy 0.6023391812865497, val accuracy 0.2
0512820512820512
Iteration 102, epoch 3
Loss 0.2964471817016602, train accuracy 0.5964912280701754, val accuracy 0.17
94871794871795
Iteration 103, epoch 3
Loss 0.24932284355163575, train accuracy 0.5964912280701754, val accuracy 0.2
1367521367521367
Iteration 104, epoch 3
Loss 1.8134257793426514, train accuracy 0.5730994152046783, val accuracy 0.21
367521367521367
Iteration 105, epoch 4
Loss 0.23830883502960204, train accuracy 0.5906432748538012, val accuracy 0.2
3931623931623933
Iteration 106, epoch 4
Loss 0.2436216115951538, train accuracy 0.6081871345029239, val accuracy 0.23
931623931623933
Iteration 107, epoch 4
Loss 0.20257115364074707, train accuracy 0.631578947368421, val accuracy 0.24
786324786324787
Iteration 108, epoch 4
Loss 0.295384955406189, train accuracy 0.6491228070175439, val accuracy 0.264
95726495726496
Iteration 109, epoch 4
Loss 0.18549047708511351, train accuracy 0.6432748538011696, val accuracy 0.2
6495726495726496
Iteration 110, epoch 4
Loss 0.021136221289634705, train accuracy 0.6608187134502924, val accuracy 0.
29914529914529914
Iteration 111, epoch 4
Loss 0.32167716026306153, train accuracy 0.6491228070175439, val accuracy 0.3
076923076923077
Iteration 112, epoch 4
Loss 0.4012619495391846, train accuracy 0.6608187134502924, val accuracy 0.32
47863247863248
Iteration 113, epoch 4
Loss 0.055325275659561156, train accuracy 0.6900584795321637, val accuracy 0.
3247863247863248
```

```
Iteration 114, epoch 4
Loss 0.3219618320465088, train accuracy 0.7426900584795322, val accuracy 0.33
33333333333333
Iteration 115, epoch 4
Loss 0.20210235118865966, train accuracy 0.7543859649122807, val accuracy 0.3
333333333333333
Iteration 116, epoch 4
Loss 0.2577682971954346, train accuracy 0.7660818713450293, val accuracy 0.30
76923076923077
Iteration 117, epoch 4
Loss 0.2809445858001709, train accuracy 0.7719298245614035, val accuracy 0.29
05982905982906
Iteration 118, epoch 4
Loss 0.3528395175933838, train accuracy 0.7719298245614035, val accuracy 0.32
47863247863248
Iteration 119, epoch 4
Loss 0.22014155387878417, train accuracy 0.7777777777777778, val accuracy 0.3
247863247863248
Iteration 120, epoch 4
Loss 0.22478175163269043, train accuracy 0.7660818713450293, val accuracy 0.3
247863247863248
Iteration 121, epoch 4
Loss 0.24880414009094237, train accuracy 0.7485380116959064, val accuracy 0.3
418803418803419
Iteration 122, epoch 4
Loss 0.13119446039199828, train accuracy 0.7602339181286549, val accuracy 0.3
6752136752136755
Iteration 123, epoch 4
Loss 0.25359699726104734, train accuracy 0.7660818713450293, val accuracy 0.3
6752136752136755
Iteration 124, epoch 4
Loss 0.23464522361755372, train accuracy 0.7660818713450293, val accuracy 0.3
58974358974359
Iteration 125, epoch 4
Loss 0.16783781051635743, train accuracy 0.7660818713450293, val accuracy 0.3
58974358974359
Iteration 126, epoch 4
Loss 0.26297948360443113, train accuracy 0.7543859649122807, val accuracy 0.3
418803418803419
Iteration 127, epoch 4
Loss 0.24897284507751466, train accuracy 0.7543859649122807, val accuracy 0.3
504273504273504
Iteration 128, epoch 4
Loss 0.21551144123077393, train accuracy 0.7660818713450293, val accuracy 0.3
504273504273504
Iteration 129, epoch 4
Loss 0.15247026681900025, train accuracy 0.7894736842105263, val accuracy 0.3
6752136752136755
Iteration 130, epoch 4
Loss 0.19899660348892212, train accuracy 0.8187134502923976, val accuracy 0.3
7606837606837606
Iteration 131, epoch 4
Loss 0.04984763562679291, train accuracy 0.8421052631578947, val accuracy 0.3
8461538461538464
Iteration 132, epoch 4
Loss 0.0359807163476944, train accuracy 0.847953216374269, val accuracy 0.384
61538461538464
```

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Iteration 133, epoch 4
Loss 0.2603175401687622, train accuracy 0.8596491228070176, val accuracy 0.39
316239316239315
Iteration 134, epoch 4
Loss 0.16877715587615966, train accuracy 0.8771929824561403, val accuracy 0.3
9316239316239315
Iteration 135, epoch 4
Loss 0.0722443401813507, train accuracy 0.8830409356725146, val accuracy 0.39
316239316239315
Iteration 136, epoch 4
Loss 0.20808067321777343, train accuracy 0.8947368421052632, val accuracy 0.3
8461538461538464
Iteration 137, epoch 4
Loss 0.10390272140502929, train accuracy 0.8771929824561403, val accuracy 0.3
9316239316239315
Iteration 138, epoch 4
Loss 0.3233689069747925, train accuracy 0.8654970760233918, val accuracy 0.42
735042735042733
Iteration 139, epoch 4
Loss 0.13939043879508972, train accuracy 0.8713450292397661, val accuracy 0.4
358974358974359
Iteration 140, epoch 5
Loss 0.08186494112014771, train accuracy 0.8654970760233918, val accuracy 0.4
52991452991453
Iteration 141, epoch 5
Loss 0.10991274118423462, train accuracy 0.8654970760233918, val accuracy 0.4
188034188034188
Iteration 142, epoch 5
Loss 0.008713442087173461, train accuracy 0.8713450292397661, val accuracy 0.
4188034188034188
Iteration 143, epoch 5
Loss 0.010512931644916535, train accuracy 0.8771929824561403, val accuracy 0.
39316239316239315
Iteration 144, epoch 5
Loss 0.1276538610458374, train accuracy 0.8538011695906432, val accuracy 0.39
316239316239315
Iteration 145, epoch 5
Loss 0.07679454684257507, train accuracy 0.8421052631578947, val accuracy 0.3
8461538461538464
Iteration 146, epoch 5
Loss 0.15014594793319702, train accuracy 0.8596491228070176, val accuracy 0.3
8461538461538464
Iteration 147, epoch 5
Loss 0.1679627776145935, train accuracy 0.8713450292397661, val accuracy 0.40
17094017094017
Iteration 148, epoch 5
Loss 0.362284517288208, train accuracy 0.8947368421052632, val accuracy 0.393
16239316239315
Iteration 149, epoch 5
Loss 0.15005269050598144, train accuracy 0.9064327485380117, val accuracy 0.4
188034188034188
Iteration 150, epoch 5
Loss 0.026237732172012328, train accuracy 0.8947368421052632, val accuracy 0.
4017094017094017
Iteration 151, epoch 5
Loss 0.020622050762176512, train accuracy 0.9005847953216374, val accuracy 0.
39316239316239315
```

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Iteration 152, epoch 5
Loss 0.013911131024360656, train accuracy 0.8888888888888888, val accuracy 0.
4017094017094017
Iteration 153, epoch 5
Loss 0.31394314765930176, train accuracy 0.8947368421052632, val accuracy 0.3
8461538461538464
Iteration 154, epoch 5
Loss 0.04966843724250793, train accuracy 0.9064327485380117, val accuracy 0.3
8461538461538464
Iteration 155, epoch 5
Loss 0.08821694254875183, train accuracy 0.9122807017543859, val accuracy 0.3
8461538461538464
Iteration 156, epoch 5
Loss 0.10925378799438476, train accuracy 0.9239766081871345, val accuracy 0.3
8461538461538464
Iteration 157, epoch 5
Loss 0.0829454779624939, train accuracy 0.9181286549707602, val accuracy 0.38
461538461538464
Iteration 158, epoch 5
Loss 0.15565412044525145, train accuracy 0.9239766081871345, val accuracy 0.4
017094017094017
Iteration 159, epoch 5
Loss 0.05195473432540894, train accuracy 0.9181286549707602, val accuracy 0.4
1025641025641024
Iteration 160, epoch 5
Loss 0.09554780721664428, train accuracy 0.9181286549707602, val accuracy 0.4
188034188034188
Iteration 161, epoch 5
Loss 0.056769651174545285, train accuracy 0.9181286549707602, val accuracy 0.
4188034188034188
Iteration 162, epoch 5
Loss 0.2172839641571045, train accuracy 0.935672514619883, val accuracy 0.418
8034188034188
Iteration 163, epoch 5
Loss 0.057357966899871826, train accuracy 0.9473684210526315, val accuracy 0.
4017094017094017
Iteration 164, epoch 5
Loss 0.0439583957195282, train accuracy 0.9415204678362573, val accuracy 0.39
316239316239315
Iteration 165, epoch 5
Loss 0.046400833129882815, train accuracy 0.9473684210526315, val accuracy 0.
41025641025641024
Iteration 166, epoch 5
Loss 0.01325560212135315, train accuracy 0.9415204678362573, val accuracy 0.4
2735042735042733
Iteration 167, epoch 5
Loss 0.026908102631568908, train accuracy 0.9415204678362573, val accuracy 0.
4188034188034188
Iteration 168, epoch 5
Loss 0.07425487041473389, train accuracy 0.9415204678362573, val accuracy 0.3
6752136752136755
Iteration 169, epoch 5
Loss 0.06504029035568237, train accuracy 0.9473684210526315, val accuracy 0.3
6752136752136755
Iteration 170, epoch 5
Loss 0.11398098468780518, train accuracy 0.9473684210526315, val accuracy 0.3
7606837606837606
```

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Iteration 171, epoch 5
Loss 0.05186837911605835, train accuracy 0.9415204678362573, val accuracy 0.3
9316239316239315
Iteration 172, epoch 5
Loss 0.24582037925720215, train accuracy 0.9532163742690059, val accuracy 0.4
1025641025641024
Iteration 173, epoch 5
Loss 0.11630628108978272, train accuracy 0.9707602339181286, val accuracy 0.4
1025641025641024
Iteration 174, epoch 5
Loss 0.006245500408113003, train accuracy 0.9707602339181286, val accuracy 0.
39316239316239315
Iteration 175, epoch 6
Loss 0.00667269378900528, train accuracy 0.9766081871345029, val accuracy 0.4
017094017094017
Iteration 176, epoch 6
Loss 0.00775393694639206, train accuracy 0.9707602339181286, val accuracy 0.3
7606837606837606
Iteration 177, epoch 6
Loss 0.021989181637763977, train accuracy 0.9707602339181286, val accuracy 0.
4017094017094017
Iteration 178, epoch 6
Loss 0.006940527260303498, train accuracy 0.9649122807017544, val accuracy 0.
4017094017094017
Iteration 179, epoch 6
Loss 0.04490247666835785, train accuracy 0.9649122807017544, val accuracy 0.4
017094017094017
Iteration 180, epoch 6
Loss 0.04132620394229889, train accuracy 0.9649122807017544, val accuracy 0.4
1025641025641024
Iteration 181, epoch 6
Loss 0.017382356524467468, train accuracy 0.9649122807017544, val accuracy 0.
4017094017094017
Iteration 182, epoch 6
Loss 0.009919820725917817, train accuracy 0.9649122807017544, val accuracy 0.
4017094017094017
Iteration 183, epoch 6
Loss 0.0031921226531267167, train accuracy 0.9649122807017544, val accuracy
0.39316239316239315
Iteration 184, epoch 6
Loss 0.035510081052780154, train accuracy 0.9649122807017544, val accuracy 0.
4017094017094017
Iteration 185, epoch 6
Loss 0.01788070946931839, train accuracy 0.9707602339181286, val accuracy 0.4
1025641025641024
Iteration 186, epoch 6
Loss 0.039505559206008914, train accuracy 0.9590643274853801, val accuracy 0.
4017094017094017
Iteration 187, epoch 6
Loss 0.010604751110076905, train accuracy 0.9590643274853801, val accuracy 0.
4017094017094017
Iteration 188, epoch 6
Loss 0.05789319276809692, train accuracy 0.9649122807017544, val accuracy 0.3
8461538461538464
Iteration 189, epoch 6
Loss 0.001978862285614014, train accuracy 0.9590643274853801, val accuracy 0.
37606837606837606
```

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Iteration 190, epoch 6
Loss 0.0005740375258028507, train accuracy 0.9590643274853801, val accuracy
0.37606837606837606
Iteration 191, epoch 6
Loss 0.00930749550461769, train accuracy 0.9298245614035088, val accuracy 0.3
6752136752136755
Iteration 192, epoch 6
Loss 0.05954815149307251, train accuracy 0.9649122807017544, val accuracy 0.3
9316239316239315
Iteration 193, epoch 6
Loss 0.04532527327537537, train accuracy 0.9532163742690059, val accuracy 0.3
7606837606837606
Iteration 194, epoch 6
Loss 0.0015503483824431895, train accuracy 0.9473684210526315, val accuracy
0.37606837606837606
Iteration 195, epoch 6
Loss 0.037074464559555056, train accuracy 0.9473684210526315, val accuracy 0.
39316239316239315
Iteration 196, epoch 6
Loss 0.04254044592380524, train accuracy 0.9415204678362573, val accuracy 0.4
017094017094017
Iteration 197, epoch 6
Loss 0.04369172155857086, train accuracy 0.9473684210526315, val accuracy 0.4
1025641025641024
Iteration 198, epoch 6
Loss 0.01322401612997055, train accuracy 0.9473684210526315, val accuracy 0.4
2735042735042733
Iteration 199, epoch 6
Loss 0.04455242156982422, train accuracy 0.9473684210526315, val accuracy 0.4
2735042735042733
Iteration 200, epoch 6
Loss 0.003652944788336754, train accuracy 0.9473684210526315, val accuracy 0.
42735042735042733
Iteration 201, epoch 6
Loss 0.021469247341156007, train accuracy 0.9473684210526315, val accuracy 0.
41025641025641024
Iteration 202, epoch 6
Loss 0.004339728131890297, train accuracy 0.9532163742690059, val accuracy 0.
4188034188034188
Iteration 203, epoch 6
Loss 0.024278931319713593, train accuracy 0.9532163742690059, val accuracy 0.
4358974358974359
Iteration 204, epoch 6
Loss 0.0025927891954779627, train accuracy 0.9532163742690059, val accuracy
0.4358974358974359
Iteration 205, epoch 6
Loss 0.4532099723815918, train accuracy 0.9590643274853801, val accuracy 0.43
58974358974359
Iteration 206, epoch 6
Loss 0.0340946227312088, train accuracy 0.9532163742690059, val accuracy 0.42
735042735042733
Iteration 207, epoch 6
Loss 0.008646708726882935, train accuracy 0.9532163742690059, val accuracy 0.
42735042735042733
Iteration 208, epoch 6
Loss 0.045475339889526366, train accuracy 0.9532163742690059, val accuracy 0.
4188034188034188
```

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Iteration 209, epoch 6
Loss 0.00012051333033014089, train accuracy 0.9590643274853801, val accuracy
0.39316239316239315
Iteration 210, epoch 7
Loss 0.005918241292238236, train accuracy 0.9590643274853801, val accuracy 0.
37606837606837606
Iteration 211, epoch 7
Loss 0.051313138008117674, train accuracy 0.9649122807017544, val accuracy 0.
38461538461538464
Iteration 212, epoch 7
Loss 0.10249041318893433, train accuracy 0.9590643274853801, val accuracy 0.3
8461538461538464
Iteration 213, epoch 7
Loss 0.09899457693099975, train accuracy 0.9649122807017544, val accuracy 0.3
9316239316239315
Iteration 214, epoch 7
Loss 0.13339771032333375, train accuracy 0.9649122807017544, val accuracy 0.3
8461538461538464
Iteration 215, epoch 7
Loss 0.0071479037404060366, train accuracy 0.9649122807017544, val accuracy
0.38461538461538464
Iteration 216, epoch 7
Loss 0.006716050952672958, train accuracy 0.9707602339181286, val accuracy 0.
41025641025641024
Iteration 217, epoch 7
Loss 0.10941781997680664, train accuracy 0.9649122807017544, val accuracy 0.4
017094017094017
Iteration 218, epoch 7
Loss 0.07867451310157776, train accuracy 0.9707602339181286, val accuracy 0.4
1025641025641024
Iteration 219, epoch 7
Loss 0.014056786894798279, train accuracy 0.9707602339181286, val accuracy 0.
42735042735042733
Iteration 220, epoch 7
Loss 0.09281114339828492, train accuracy 0.9707602339181286, val accuracy 0.4
2735042735042733
Iteration 221, epoch 7
Loss 0.017919936776161195, train accuracy 0.9766081871345029, val accuracy 0.
41025641025641024
Iteration 222, epoch 7
Loss 0.04371199011802673, train accuracy 0.9649122807017544, val accuracy 0.3
8461538461538464
Iteration 223, epoch 7
Loss 0.01640034019947052, train accuracy 0.9590643274853801, val accuracy 0.3
7606837606837606
Iteration 224, epoch 7
Loss 0.018638236820697783, train accuracy 0.9532163742690059, val accuracy 0.
38461538461538464
Iteration 225, epoch 7
Loss 0.06154048442840576, train accuracy 0.9649122807017544, val accuracy 0.3
8461538461538464
Iteration 226, epoch 7
Loss 0.06410870552062989, train accuracy 0.9649122807017544, val accuracy 0.3
8461538461538464
Iteration 227, epoch 7
Loss 4.6346460294444116e-06, train accuracy 0.9649122807017544, val accuracy
0.36752136752136755
```

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Iteration 228, epoch 7
Loss 0.03811720013618469, train accuracy 0.9649122807017544, val accuracy 0.3
8461538461538464
Iteration 229, epoch 7
Loss 0.0033905338495969772, train accuracy 0.9766081871345029, val accuracy
0.41025641025641024
Iteration 230, epoch 7
Loss 0.005237145349383354, train accuracy 0.9766081871345029, val accuracy 0.
41025641025641024
Iteration 231, epoch 7
Loss 0.2548159122467041, train accuracy 0.9883040935672515, val accuracy 0.39
316239316239315
Iteration 232, epoch 7
Loss 0.022026510536670686, train accuracy 0.9883040935672515, val accuracy 0.
39316239316239315
Iteration 233, epoch 7
Loss 0.027342551946640016, train accuracy 0.9883040935672515, val accuracy 0.
39316239316239315
Iteration 234, epoch 7
Loss 0.033790960907936096, train accuracy 0.9941520467836257, val accuracy 0.
4017094017094017
Iteration 235, epoch 7
Loss 0.3095940351486206, train accuracy 0.9941520467836257, val accuracy 0.38
461538461538464
Iteration 236, epoch 7
Loss 0.030306339263916016, train accuracy 0.9941520467836257, val accuracy 0.
37606837606837606
Iteration 237, epoch 7
Loss 0.01037122830748558, train accuracy 0.9883040935672515, val accuracy 0.4
017094017094017
Iteration 238, epoch 7
Loss 0.000429763738065958, train accuracy 0.9883040935672515, val accuracy 0.
4017094017094017
Iteration 239, epoch 7
Loss 0.08157866597175598, train accuracy 0.9824561403508771, val accuracy 0.3
58974358974359
Iteration 240, epoch 7
Loss 0.0038052238523960114, train accuracy 0.9766081871345029, val accuracy
0.3504273504273504
Iteration 241, epoch 7
Loss 0.10111062526702881, train accuracy 0.9707602339181286, val accuracy 0.3
504273504273504
Iteration 242, epoch 7
Loss 0.08382663726806641, train accuracy 0.9766081871345029, val accuracy 0.3
333333333333333
Iteration 243, epoch 7
Loss 0.14319710731506347, train accuracy 0.9766081871345029, val accuracy 0.3
58974358974359
Iteration 244, epoch 7
Loss 0.0012029323261231184, train accuracy 0.9824561403508771, val accuracy
0.36752136752136755
Iteration 245, epoch 8
Loss 0.0023370591923594477, train accuracy 0.9824561403508771, val accuracy
0.37606837606837606
Iteration 246, epoch 8
Loss 0.00951715260744095, train accuracy 0.9766081871345029, val accuracy 0.3
7606837606837606
```

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Iteration 247, epoch 8
Loss 0.010837689787149 43, train accuracy 0.9766081871345029, val accuracy 0.3
8461538461538464
Iteration 248, epoch 8
Loss 0.022067241370677948, train accuracy 0.9766081871345029, val accuracy 0.
38461538461538464
Iteration 249, epoch 8
Loss 0.013433919847011566, train accuracy 0.9766081871345029, val accuracy 0.
37606837606837606
Iteration 250, epoch 8
Loss 0.018740005791187286, train accuracy 0.9766081871345029, val accuracy 0.
39316239316239315
Iteration 251, epoch 8
Loss 0.031351155042648314, train accuracy 0.9766081871345029, val accuracy 0.
39316239316239315
Iteration 252, epoch 8
Loss 0.022237142920494078, train accuracy 0.9766081871345029, val accuracy 0.
39316239316239315
Iteration 253, epoch 8
Loss 0.0001457762671634555, train accuracy 0.9649122807017544, val accuracy
0.39316239316239315
Iteration 254, epoch 8
Loss 0.03944455087184906, train accuracy 0.9707602339181286, val accuracy 0.3
9316239316239315
Iteration 255, epoch 8
Loss 1.016512542264536e-05, train accuracy 0.9707602339181286, val accuracy
0.38461538461538464
Iteration 256, epoch 8
Loss 0.0046462021768093106, train accuracy 0.9707602339181286, val accuracy
0.38461538461538464
Iteration 257, epoch 8
Loss 0.003356918692588806, train accuracy 0.9766081871345029, val accuracy 0.
38461538461538464
Iteration 258, epoch 8
Loss 0.0004928589798510075, train accuracy 0.9766081871345029, val accuracy
0.39316239316239315
Iteration 259, epoch 8
Loss 0.002341932989656925, train accuracy 0.9766081871345029, val accuracy 0.
39316239316239315
Iteration 260, epoch 8
Loss 0.0010797636583447455, train accuracy 0.9824561403508771, val accuracy
0.38461538461538464
Iteration 261, epoch 8
Loss 0.0005300003103911877, train accuracy 0.9824561403508771, val accuracy
0.37606837606837606
Iteration 262, epoch 8
Loss 0.006214498355984688, train accuracy 0.9824561403508771, val accuracy 0.
37606837606837606
Iteration 263, epoch 8
Loss 0.009396775811910629, train accuracy 0.9824561403508771, val accuracy 0.
38461538461538464
Iteration 264, epoch 8
Loss 0.0034250237047672273, train accuracy 0.9824561403508771, val accuracy
0.38461538461538464
Iteration 265, epoch 8
Loss 0.015060891211032868, train accuracy 0.9824561403508771, val accuracy 0.
38461538461538464
```

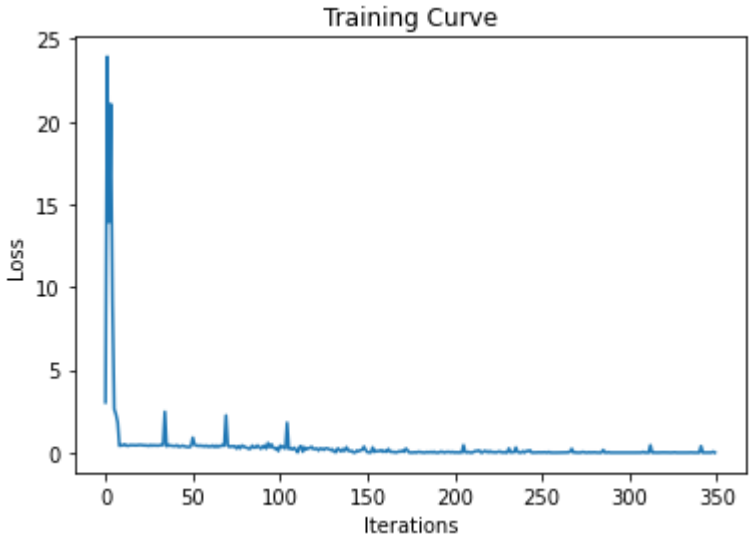
```
Iteration 266, epoch 8
Loss 0.05675280690193176, train accuracy 0.9883040935672515, val accuracy 0.3
8461538461538464
Iteration 267, epoch 8
Loss 0.2313441514968872, train accuracy 0.9883040935672515, val accuracy 0.40
17094017094017
Iteration 268, epoch 8
Loss 0.0023194724693894387, train accuracy 0.9941520467836257, val accuracy
0.4017094017094017
Iteration 269, epoch 8
Loss 0.02504553198814392, train accuracy 0.9941520467836257, val accuracy 0.3
9316239316239315
Iteration 270, epoch 8
Loss 8.940198313212022e-06, train accuracy 0.9941520467836257, val accuracy
0.37606837606837606
Iteration 271, epoch 8
Loss 0.003596191853284836, train accuracy 0.9941520467836257, val accuracy 0.
36752136752136755
Iteration 272, epoch 8
Loss 0.002298377268016338, train accuracy 0.9941520467836257, val accuracy 0.
358974358974359
Iteration 273, epoch 8
Loss 0.0390965461730957, train accuracy 0.9941520467836257, val accuracy 0.34
18803418803419
Iteration 274, epoch 8
Loss 0.028046572208404542, train accuracy 0.9883040935672515, val accuracy 0.
3504273504273504
Iteration 275, epoch 8
Loss 0.0024694060906767846, train accuracy 0.9883040935672515, val accuracy
0.3418803418803419
Iteration 276, epoch 8
Loss 0.0016925804316997527, train accuracy 0.9883040935672515, val accuracy
0.3247863247863248
Iteration 277, epoch 8
Loss 0.02508276402950287, train accuracy 0.9824561403508771, val accuracy 0.3
162393162393162
Iteration 278, epoch 8
Loss 0.004360158368945122, train accuracy 0.9824561403508771, val accuracy 0.
3162393162393162
Iteration 279, epoch 8
Loss 0.017108945176005363, train accuracy 0.9824561403508771, val accuracy 0.
3162393162393162
Iteration 280, epoch 9
Loss 0.02231365144252777, train accuracy 0.9824561403508771, val accuracy 0.3
162393162393162
Iteration 281, epoch 9
Loss 0.005618681758642196, train accuracy 0.9824561403508771, val accuracy 0.
3162393162393162
Iteration 282, epoch 9
Loss 0.004307839274406433, train accuracy 0.9824561403508771, val accuracy 0.
3247863247863248
Iteration 283, epoch 9
Loss 0.0010854832828044892, train accuracy 0.9824561403508771, val accuracy
0.3247863247863248
Iteration 284, epoch 9
Loss 0.00011397551279515027, train accuracy 0.9824561403508771, val accuracy
0.3333333333333333
```

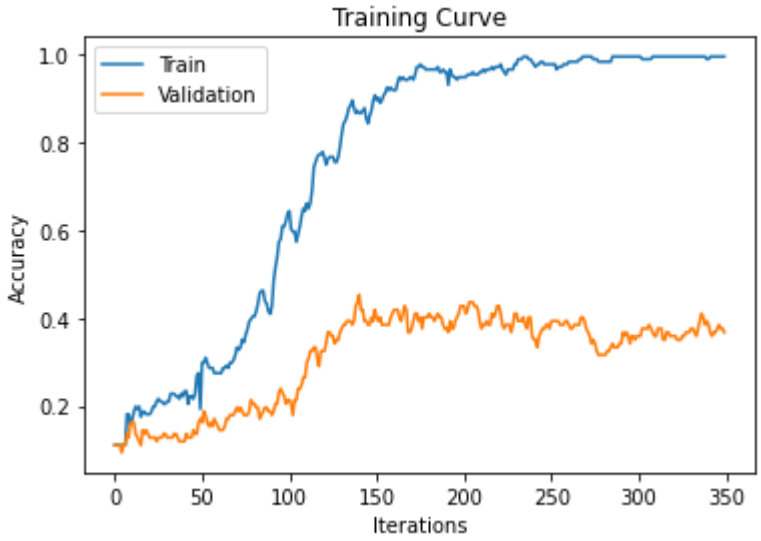
```
Iteration 285, epoch 9
Loss 0.16378047466278076, train accuracy 0.9941520467836257, val accuracy 0.3
418803418803419
Iteration 286, epoch 9
Loss 0.0029044851660728456, train accuracy 0.9941520467836257, val accuracy
0.3333333333333333
Iteration 287, epoch 9
Loss 0.0016610855236649513, train accuracy 0.9941520467836257, val accuracy
0.3333333333333333
Iteration 288, epoch 9
Loss 0.027244645357131957, train accuracy 0.9941520467836257, val accuracy 0.
3333333333333333
Iteration 289, epoch 9
Loss 0.0020343953743577003, train accuracy 0.9941520467836257, val accuracy
0.3418803418803419
Iteration 290, epoch 9
Loss 0.0028613513335585595, train accuracy 0.9941520467836257, val accuracy
0.3418803418803419
Iteration 291, epoch 9
Loss 0.002728068269789219, train accuracy 0.9941520467836257, val accuracy 0.
36752136752136755
Iteration 292, epoch 9
Loss 0.0001438877312466502, train accuracy 0.9941520467836257, val accuracy
0.358974358974359
Iteration 293, epoch 9
Loss 0.0007562266197055578, train accuracy 0.9941520467836257, val accuracy
0.36752136752136755
Iteration 294, epoch 9
Loss 0.00335293784737587, train accuracy 0.9941520467836257, val accuracy 0.3
58974358974359
Iteration 295, epoch 9
Loss 0.0021892931312322617, train accuracy 0.9941520467836257, val accuracy
0.3418803418803419
Iteration 296, epoch 9
Loss 3.5782638587988916e-05, train accuracy 0.9941520467836257, val accuracy
0.358974358974359
Iteration 297, epoch 9
Loss 0.0008234378881752491, train accuracy 0.9941520467836257, val accuracy
0.358974358974359
Iteration 298, epoch 9
Loss 0.0001337246620096 2664, train accuracy 0.9941520467836257, val accuracy
0.3504273504273504
Iteration 299, epoch 9
Loss 0.003959452360868454, train accuracy 0.9941520467836257, val accuracy 0.
358974358974359
Iteration 300, epoch 9
Loss 0.001562860794365406, train accuracy 0.9941520467836257, val accuracy 0.
358974358974359
Iteration 301, epoch 9
Loss 1.4851809828542173e-05, train accuracy 0.9941520467836257, val accuracy
0.358974358974359
Iteration 302, epoch 9
Loss 0.025410208106040954, train accuracy 0.9883040935672515, val accuracy 0.
37606837606837606
Iteration 303, epoch 9
Loss 0.0024720560759305954, train accuracy 0.9883040935672515, val accuracy
0.37606837606837606
```

```
Iteration 304, epoch 9
Loss 0.0004430013708770275, train accuracy 0.9883040935672515, val accuracy
0.37606837606837606
Iteration 305, epoch 9
Loss 0.0005224463995546103, train accuracy 0.9883040935672515, val accuracy
0.37606837606837606
Iteration 306, epoch 9
Loss 0.009651963412761689, train accuracy 0.9883040935672515, val accuracy 0.
38461538461538464
Iteration 307, epoch 9
Loss 0.005789543315768242, train accuracy 0.9883040935672515, val accuracy 0.
37606837606837606
Iteration 308, epoch 9
Loss 0.04620892107486725, train accuracy 0.9941520467836257, val accuracy 0.3
6752136752136755
Iteration 309, epoch 9
Loss 0.0009331092238426209, train accuracy 0.9941520467836257, val accuracy
0.358974358974359
Iteration 310, epoch 9
Loss 3.695377381518483e-06, train accuracy 0.9941520467836257, val accuracy
0.358974358974359
Iteration 311, epoch 9
Loss 0.0002886923979967833, train accuracy 0.9941520467836257, val accuracy
0.37606837606837606
Iteration 312, epoch 9
Loss 0.449230432510376, train accuracy 0.9941520467836257, val accuracy 0.376
06837606837606
Iteration 313, epoch 9
Loss 0.0010667472146451474, train accuracy 0.9941520467836257, val accuracy
0.37606837606837606
Iteration 314, epoch 9
Loss 0.008647731505334377, train accuracy 0.9941520467836257, val accuracy 0.
3504273504273504
Iteration 315, epoch 10
Loss 0.0026533046737313272, train accuracy 0.9941520467836257, val accuracy
0.3504273504273504
Iteration 316, epoch 10
Loss 1.7273626872338356e-05, train accuracy 0.9941520467836257, val accuracy
0.36752136752136755
Iteration 317, epoch 10
Loss 0.007990299165248871, train accuracy 0.9941520467836257, val accuracy 0.
36752136752136755
Iteration 318, epoch 10
Loss 0.0066743135452270504, train accuracy 0.9941520467836257, val accuracy
0.358974358974359
Iteration 319, epoch 10
Loss 0.011619924008846283, train accuracy 0.9941520467836257, val accuracy 0.
358974358974359
Iteration 320, epoch 10
Loss 0.014597366750240325, train accuracy 0.9941520467836257, val accuracy 0.
358974358974359
Iteration 321, epoch 10
Loss 0.008959446102380753, train accuracy 0.9941520467836257, val accuracy 0.
358974358974359
Iteration 322, epoch 10
Loss 0.0012425047345459462, train accuracy 0.9941520467836257, val accuracy
0.3504273504273504
```

```
Iteration 323, epoch 10
Loss 0.005687663704156876, train accuracy 0.9941520467836257, val accuracy 0.
3504273504273504
Iteration 324, epoch 10
Loss 0.00018144261557608842, train accuracy 0.9941520467836257, val accuracy
0.3504273504273504
Iteration 325, epoch 10
Loss 0.013659346103668212, train accuracy 0.9941520467836257, val accuracy 0.
358974358974359
Iteration 326, epoch 10
Loss 0.02004127949476242, train accuracy 0.9941520467836257, val accuracy 0.3
58974358974359
Iteration 327, epoch 10
Loss 0.0011376050300896169, train accuracy 0.9941520467836257, val accuracy
0.36752136752136755
Iteration 328, epoch 10
Loss 0.00018005002057179808, train accuracy 0.9941520467836257, val accuracy
0.36752136752136755
Iteration 329, epoch 10
Loss 0.0005267723463475704, train accuracy 0.9941520467836257, val accuracy
0.36752136752136755
Iteration 330, epoch 10
Loss 0.003101569041609764, train accuracy 0.9941520467836257, val accuracy 0.
37606837606837606
Iteration 331, epoch 10
Loss 0.00012931991368532182, train accuracy 0.9941520467836257, val accuracy
0.37606837606837606
Iteration 332, epoch 10
Loss 7.247222238220275e-05, train accuracy 0.9941520467836257, val accuracy
0.36752136752136755
Iteration 333, epoch 10
Loss 0.0006356491707265377, train accuracy 0.9941520467836257, val accuracy
0.358974358974359
Iteration 334, epoch 10
Loss 0.0026228830218315126, train accuracy 0.9941520467836257, val accuracy
0.37606837606837606
Iteration 335, epoch 10
Loss 0.01133190244436264, train accuracy 0.9941520467836257, val accuracy 0.3
9316239316239315
Iteration 336, epoch 10
Loss 0.003852482885122299, train accuracy 0.9941520467836257, val accuracy 0.
41025641025641024
Iteration 337, epoch 10
Loss 4.5302649959921835e-05, train accuracy 0.9941520467836257, val accuracy
0.4017094017094017
Iteration 338, epoch 10
Loss 0.002992957830429077, train accuracy 0.9941520467836257, val accuracy 0.
38461538461538464
Iteration 339, epoch 10
Loss 1.0790264786919579e-05, train accuracy 0.9883040935672515, val accuracy
0.39316239316239315
Iteration 340, epoch 10
Loss 0.0005921064876019955, train accuracy 0.9883040935672515, val accuracy
0.38461538461538464
Iteration 341, epoch 10
Loss 0.39411590099334715, train accuracy 0.9941520467836257, val accuracy 0.3
6752136752136755
```

```
Iteration 342, epoch 10
Loss 0.0023563088849186896, train accuracy 0.9941520467836257, val accuracy
0.358974358974359
Iteration 343, epoch 10
Loss 0.003049025870859623, train accuracy 0.9941520467836257, val accuracy 0.
36752136752136755
Iteration 344, epoch 10
Loss 0.0007495464291423559, train accuracy 0.9941520467836257, val accuracy
0.36752136752136755
Iteration 345, epoch 10
Loss 0.001026812382042408, train accuracy 0.9941520467836257, val accuracy 0.
37606837606837606
Iteration 346, epoch 10
Loss 0.016088657081127167, train accuracy 0.9941520467836257, val accuracy 0.
38461538461538464
Iteration 347, epoch 10
Loss 0.005235067754983902, train accuracy 0.9941520467836257, val accuracy 0.
37606837606837606
Iteration 348, epoch 10
Loss 0.06036101579666138, train accuracy 0.9941520467836257, val accuracy 0.3
7606837606837606
Iteration 349, epoch 10
Loss 0.00014649749209638685, train accuracy 0.9941520467836257, val accuracy
0.36752136752136755
```






```
Final training accuracy: 0.9941520467836257
Final validation accuracy: 0.36752136752136755
```

3. Hyperparameter Search [10 pt]

Part (a) - 1 pt

List 3 hyperparameters that you think are most worth tuning. Choose at least one hyperparameter related to the model architecture.

1. Number of channels and hidden units in the network
2. Batch size
3. Number of epochs

Part (b) - 5 pt

Tune the hyperparameters you listed in Part (a), trying as many values as you need to until you feel satisfied that you are getting a good model. Plot the training curve of at least 4 different hyperparameter settings.

In [32]:
```
# Prepare data
data_prep("./drive/MyDrive/Lab3_Dataset/Lab3_Gestures_Summer", 0.1)
```

In [9]:
```
# Load data
training_set, validation_set, testing_set = create_sets(
    ".", ".", ".")

# Initialize model
model_CNN = CNN()
model_CNN.to(device)

# Train model
train(model_CNN, training_set, validation_set, num_epochs=30, batch_size=600,
lr=0.002)
```

```
Iteration 0, epoch 1
Loss 0.015949438412984213, train accuracy 0.11024930747922437, val accuracy
0.1111111111111111
Iteration 1, epoch 1
Loss 0.7606498209635416, train accuracy 0.10526315789473684, val accuracy 0.1
111111111111111
Iteration 2, epoch 1
Loss 0.38035273234049477, train accuracy 0.1113573407202216, val accuracy 0.1
111111111111111
Iteration 3, epoch 1
Loss 13.456954956054688, train accuracy 0.11246537396121883, val accuracy 0.1
2077294685990338
Iteration 4, epoch 2
Loss 0.004494781494140625, train accuracy 0.1290858725761773, val accuracy 0.
08695652173913043
Iteration 5, epoch 2
Loss 0.004045914411544799, train accuracy 0.15900277008310248, val accuracy
0.1497584541062802
Iteration 6, epoch 2
Loss 0.0035950573285420738, train accuracy 0.18227146814404432, val accuracy
0.15458937198067632
Iteration 7, epoch 2
Loss 0.44268550872802737, train accuracy 0.12354570637119114, val accuracy 0.
12077294685990338
Iteration 8, epoch 3
Loss 0.003796702226003011, train accuracy 0.16620498614958448, val accuracy
0.14492753623188406
Iteration 9, epoch 3
Loss 0.0035368096828460693, train accuracy 0.15734072022160664, val accuracy
0.12560386473429952
Iteration 10, epoch 3
Loss 0.00357921044031779, train accuracy 0.15900277008310248, val accuracy 0.
12560386473429952
Iteration 11, epoch 3
Loss 0.4396143913269043, train accuracy 0.15013850415512464, val accuracy 0.1
1594202898550725
Iteration 12, epoch 4
Loss 0.00359049121538798, train accuracy 0.14736842105263157, val accuracy 0.
11594202898550725
Iteration 13, epoch 4
Loss 0.003609662850697835, train accuracy 0.1484764542936288, val accuracy 0.
11594202898550725
Iteration 14, epoch 4
Loss 0.0035752201080322264, train accuracy 0.15734072022160664, val accuracy
0.11594202898550725
Iteration 15, epoch 4
Loss 0.38802852630615237, train accuracy 0.16565096952908587, val accuracy 0.
12560386473429952
Iteration 16, epoch 5
Loss 0.0035069469610850014, train accuracy 0.17950138504155125, val accuracy
0.12077294685990338
Iteration 17, epoch 5
Loss 0.003483418623606364, train accuracy 0.21329639889196675, val accuracy
0.1642512077294686
Iteration 18, epoch 5
Loss 0.0033504855632781982, train accuracy 0.29418282548476454, val accuracy
0.2463768115942029
```

```
Iteration 19, epoch 5
Loss 0.46515302658081054, train accuracy 0.325207756232687, val accuracy 0.28
019323671497587
Iteration 20, epoch 6
Loss 0.0032790484031041465, train accuracy 0.33407202216066484, val accuracy
0.2753623188405797
Iteration 21, epoch 6
Loss 0.003027240037918091, train accuracy 0.3401662049861496, val accuracy 0.
21739130434782608
Iteration 22, epoch 6
Loss 0.003095819155375163, train accuracy 0.40110803324099725, val accuracy
0.3140096618357488
Iteration 23, epoch 6
Loss 0.3710639238357544, train accuracy 0.464819944598338, val accuracy 0.352
6570048309179
Iteration 24, epoch 7
Loss 0.00271140456199646, train accuracy 0.5346260387811634, val accuracy 0.4
5893719806763283
Iteration 25, epoch 7
Loss 0.0022653541962305707, train accuracy 0.34238227146814404, val accuracy
0.2753623188405797
Iteration 26, epoch 7
Loss 0.005151294072469076, train accuracy 0.5401662049861495, val accuracy 0.
4057971014492754
Iteration 27, epoch 7
Loss 0.24412753582000732, train accuracy 0.4548476454293629, val accuracy 0.3
2367149758454106
Iteration 28, epoch 8
Loss 0.0027513515949249266, train accuracy 0.3994459833795014, val accuracy
0.28019323671497587
Iteration 29, epoch 8
Loss 0.002941568692525228, train accuracy 0.36509695290858724, val accuracy
0.2608695652173913
Iteration 30, epoch 8
Loss 0.0031250617901484173, train accuracy 0.33739612188365653, val accuracy
0.23671497584541062
Iteration 31, epoch 8
Loss 0.4303446769714355, train accuracy 0.31966759002770084, val accuracy 0.2
4154589371980675
Iteration 32, epoch 9
Loss 0.0032506394386291504, train accuracy 0.3152354570637119, val accuracy
0.2463768115942029
Iteration 33, epoch 9
Loss 0.003256627122561137, train accuracy 0.3346260387811634, val accuracy 0.
2560386473429952
Iteration 34, epoch 9
Loss 0.0032290097077687582, train accuracy 0.3700831024930748, val accuracy
0.2318840579710145
Iteration 35, epoch 9
Loss 0.37711899280548095, train accuracy 0.42382271468144045, val accuracy 0.
2946859903381642
Iteration 36, epoch 10
Loss 0.0027225029468536375, train accuracy 0.3861495844875346, val accuracy
0.30917874396135264
Iteration 37, epoch 10
Loss 0.003033383091290792, train accuracy 0.48033240997229915, val accuracy
0.34782608695652173
```

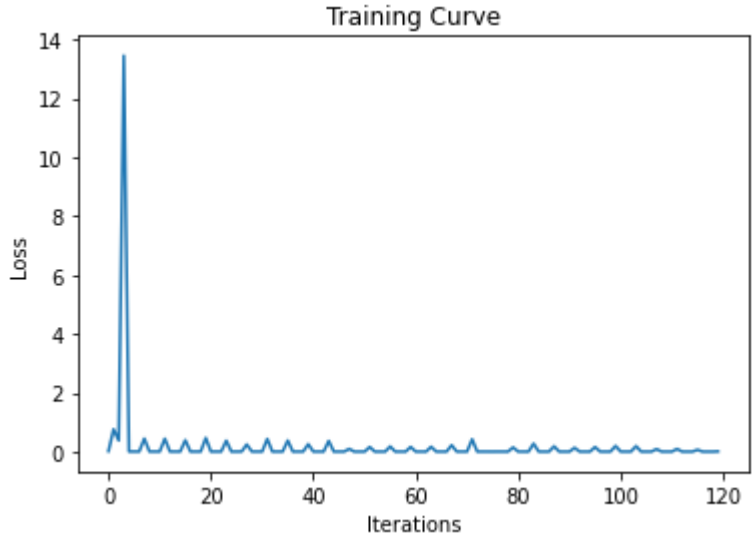
```
Iteration 38, epoch 10
Loss 0.0025950008630752563, train accuracy 0.4692520775623269, val accuracy
0.3140096618357488
Iteration 39, epoch 10
Loss 0.2535393476486206, train accuracy 0.45318559556786703, val accuracy 0.3
0917874396135264
Iteration 40, epoch 11
Loss 0.0027605265378952025, train accuracy 0.46038781163434905, val accuracy
0.30917874396135264
Iteration 41, epoch 11
Loss 0.0028106729189554852, train accuracy 0.47257617728531853, val accuracy
0.32367149758454106
Iteration 42, epoch 11
Loss 0.0027403050661087038, train accuracy 0.5096952908587258, val accuracy
0.33816425120772947
Iteration 43, epoch 11
Loss 0.3629633665084839, train accuracy 0.5645429362880886, val accuracy 0.39
61352657004831
Iteration 44, epoch 12
Loss 0.0021223700046539306, train accuracy 0.5662049861495845, val accuracy
0.4396135265700483
Iteration 45, epoch 12
Loss 0.0020908025900522867, train accuracy 0.6227146814404432, val accuracy
0.46859903381642515
Iteration 46, epoch 12
Loss 0.0019755792617797852, train accuracy 0.6592797783933518, val accuracy
0.4927536231884058
Iteration 47, epoch 12
Loss 0.09297412633895874, train accuracy 0.6387811634349031, val accuracy 0.4
8792270531400966
Iteration 48, epoch 13
Loss 0.0019274592399597169, train accuracy 0.6731301939058172, val accuracy
0.5072463768115942
Iteration 49, epoch 13
Loss 0.00155641237894694, train accuracy 0.6869806094182825, val accuracy 0.4
8792270531400966
Iteration 50, epoch 13
Loss 0.0015512260794639588, train accuracy 0.7052631578947368, val accuracy
0.4927536231884058
Iteration 51, epoch 13
Loss 0.1578097701072693, train accuracy 0.6698060941828254, val accuracy 0.47
82608695652174
Iteration 52, epoch 14
Loss 0.0017422270774841310, train accuracy 0.7141274238227147, val accuracy 0.
4927536231884058
Iteration 53, epoch 14
Loss 0.0014278074105580649, train accuracy 0.6908587257617729, val accuracy
0.4444444444444444
Iteration 54, epoch 14
Loss 0.001651110847791036, train accuracy 0.718005540166205, val accuracy 0.4
830917874396135
Iteration 55, epoch 14
Loss 0.1757429361343384, train accuracy 0.7307479224376732, val accuracy 0.54
58937198067633
Iteration 56, epoch 15
Loss 0.001236359973748525, train accuracy 0.6742382271468144, val accuracy 0.
5603864734299517
```

```
Iteration 57, epoch 15
Loss 0.0019243272145589192, train accuracy 0.7301939058171745, val accuracy
0.45893719806763283
Iteration 58, epoch 15
Loss 0.0013929652174313864, train accuracy 0.6637119113573408, val accuracy
0.34299516908212563
Iteration 59, epoch 15
Loss 0.15960273742675782, train accuracy 0.6470914127423822, val accuracy 0.3
4299516908212563
Iteration 60, epoch 16
Loss 0.0018734526634216308, train accuracy 0.6747922437673131, val accuracy
0.36231884057971014
Iteration 61, epoch 16
Loss 0.0018286927541097005, train accuracy 0.7013850415512466, val accuracy
0.42028985507246375
Iteration 62, epoch 16
Loss 0.0014081847667694 09, train accuracy 0.650415512465374, val accuracy 0.4
7342995169082125
Iteration 63, epoch 16
Loss 0.16485188007354737, train accuracy 0.6759002770083102, val accuracy 0.4
782608695652174
Iteration 64, epoch 17
Loss 0.0019233852624893188, train accuracy 0.6975069252077563, val accuracy
0.42028985507246375
Iteration 65, epoch 17
Loss 0.0016293306152025 86, train accuracy 0.585595567867036, val accuracy 0.3
4299516908212563
Iteration 66, epoch 17
Loss 0.0020881150166193645, train accuracy 0.532409972299169, val accuracy 0.
3140096618357488
Iteration 67, epoch 17
Loss 0.21909501552581787, train accuracy 0.5096952908587258, val accuracy 0.3
140096618357488
Iteration 68, epoch 18
Loss 0.0023973482847213746, train accuracy 0.5119113573407202, val accuracy
0.3188405797101449
Iteration 69, epoch 18
Loss 0.002395243247350057, train accuracy 0.525207756232687, val accuracy 0.3
2367149758454106
Iteration 70, epoch 18
Loss 0.0023631481329600018, train accuracy 0.5573407202216066, val accuracy
0.3285024154589372
Iteration 71, epoch 18
Loss 0.4191935062408447, train accuracy 0.5645429362880886, val accuracy 0.33
333333333333
Iteration 72, epoch 19
Loss 0.002332901954650879, train accuracy 0.5883656509695291, val accuracy 0.
34782608695652173
Iteration 73, epoch 19
Loss 0.00194931427637736, train accuracy 0.614404432132964, val accuracy 0.38
64734299516908
Iteration 74, epoch 19
Loss 0.0019347679615020752, train accuracy 0.6277008310249308, val accuracy
0.42995169082125606
Iteration 75, epoch 19
Loss 0.0006592022720724345, train accuracy 0.6221606648199446, val accuracy
0.4782608695652174
```

```
Iteration 76, epoch 20
Loss 0.0020658141374588013, train accuracy 0.6670360110803324, val accuracy
0.4492753623188406
Iteration 77, epoch 20
Loss 0.0016726706425348918, train accuracy 0.6681440443213297, val accuracy
0.4251207729468599
Iteration 78, epoch 20
Loss 0.0016118998328844706, train accuracy 0.6725761772853186, val accuracy
0.43478260869565216
Iteration 79, epoch 20
Loss 0.14354560375213624, train accuracy 0.679224376731302, val accuracy 0.42
028985507246375
Iteration 80, epoch 21
Loss 0.001661634345849355, train accuracy 0.7185595567867036, val accuracy 0.
4396135265700483
Iteration 81, epoch 21
Loss 0.0014316789309183756, train accuracy 0.7595567867036012, val accuracy
0.4927536231884058
Iteration 82, epoch 21
Loss 0.0010542425513267518, train accuracy 0.720775623268698, val accuracy 0.
4975845410628019
Iteration 83, epoch 21
Loss 0.2730278015136719, train accuracy 0.7922437673130194, val accuracy 0.53
14009661835749
Iteration 84, epoch 22
Loss 0.0009545328219731649, train accuracy 0.7994459833795013, val accuracy
0.4975845410628019
Iteration 85, epoch 22
Loss 0.0010579422116279602, train accuracy 0.7911357340720222, val accuracy
0.5024154589371981
Iteration 86, epoch 22
Loss 0.0010406456391016642, train accuracy 0.7878116343490305, val accuracy
0.5314009661835749
Iteration 87, epoch 22
Loss 0.18004779815673827, train accuracy 0.7750692520775623, val accuracy 0.5
169082125603864
Iteration 88, epoch 23
Loss 0.0010511902968088785, train accuracy 0.7750692520775623, val accuracy
0.5217391304347826
Iteration 89, epoch 23
Loss 0.0011640526851018269, train accuracy 0.7767313019390581, val accuracy
0.5410628019323671
Iteration 90, epoch 23
Loss 0.0010229027271270751, train accuracy 0.7822714681440444, val accuracy
0.5652173913043478
Iteration 91, epoch 23
Loss 0.1300971746444702, train accuracy 0.7734072022160665, val accuracy 0.48
792270531400966
Iteration 92, epoch 24
Loss 0.001197260320186615, train accuracy 0.7590027700831025, val accuracy 0.
4492753623188406
Iteration 93, epoch 24
Loss 0.0013012779752413432, train accuracy 0.7745152354570637, val accuracy
0.45893719806763283
Iteration 94, epoch 24
Loss 0.0011595329642295838, train accuracy 0.7977839335180056, val accuracy
0.4975845410628019
```

```
Iteration 95, epoch 24
Loss 0.15611894130706788, train accuracy 0.7013850415512466, val accuracy 0.5
169082125603864
Iteration 96, epoch 25
Loss 0.0019767651955286663, train accuracy 0.7867036011080333, val accuracy
0.4444444444444444
Iteration 97, epoch 25
Loss 0.001203695038954417, train accuracy 0.6808864265927977, val accuracy 0.
3719806763285024
Iteration 98, epoch 25
Loss 0.0017042871316274007, train accuracy 0.628808864265928, val accuracy 0.
3671497584541063
Iteration 99, epoch 25
Loss 0.19260228872299195, train accuracy 0.6138504155124653, val accuracy 0.3
57487922705314
Iteration 100, epoch 26
Loss 0.0021958778301874797, train accuracy 0.624376731301939, val accuracy 0.
3719806763285024
Iteration 101, epoch 26
Loss 0.002027398149172465, train accuracy 0.6670360110803324, val accuracy 0.
3961352657004831
Iteration 102, epoch 26
Loss 0.0017152192195256 55, train accuracy 0.7445983379501385, val accuracy 0.
4444444444444444
Iteration 103, epoch 26
Loss 0.18661088943481446, train accuracy 0.7961218836565097, val accuracy 0.5
458937198067633
Iteration 104, epoch 27
Loss 0.0009577945868174235, train accuracy 0.7833795013850415, val accuracy
0.5942028985507246
Iteration 105, epoch 27
Loss 0.0012189552187919616, train accuracy 0.7911357340720222, val accuracy
0.5942028985507246
Iteration 106, epoch 27
Loss 0.0015671210487683614, train accuracy 0.8177285318559557, val accuracy
0.5410628019323671
Iteration 107, epoch 27
Loss 0.08759465217590331, train accuracy 0.7545706371191135, val accuracy 0.4
5410628019323673
Iteration 108, epoch 28
Loss 0.0013185643156369527, train accuracy 0.7229916897506925, val accuracy
0.4251207729468599
Iteration 109, epoch 28
Loss 0.0015521884957949322, train accuracy 0.7445983379501385, val accuracy
0.4396135265700483
Iteration 110, epoch 28
Loss 0.0013990061481793721, train accuracy 0.7822714681440444, val accuracy
0.5217391304347826
Iteration 111, epoch 28
Loss 0.09331817626953125, train accuracy 0.8055401662049861, val accuracy 0.5
700483091787439
Iteration 112, epoch 29
Loss 0.0009946192304293314, train accuracy 0.8083102493074792, val accuracy
0.5555555555555556
Iteration 113, epoch 29
Loss 0.000987524688243866, train accuracy 0.8027700831024931, val accuracy 0.
5603864734299517
```

```
Iteration 114, epoch 29
Loss 0.0010784117380777994, train accuracy 0.8293628808864266, val accuracy
0.5700483091787439
Iteration 115, epoch 29
Loss 0.06317309141159058, train accuracy 0.8421052631578947, val accuracy 0.5
845410628019324
Iteration 116, epoch 30
Loss 0.0007881467044353485, train accuracy 0.8498614958448754, val accuracy
0.6135265700483091
Iteration 117, epoch 30
Loss 0.0007825998961925507, train accuracy 0.8614958448753463, val accuracy
0.6086956521739131
Iteration 118, epoch 30
Loss 0.0006612770259380341, train accuracy 0.8653739612188366, val accuracy
0.5990338164251208
Iteration 119, epoch 30
Loss 0.00858512669801712, train accuracy 0.8393351800554016, val accuracy 0.6
183574879227053
```

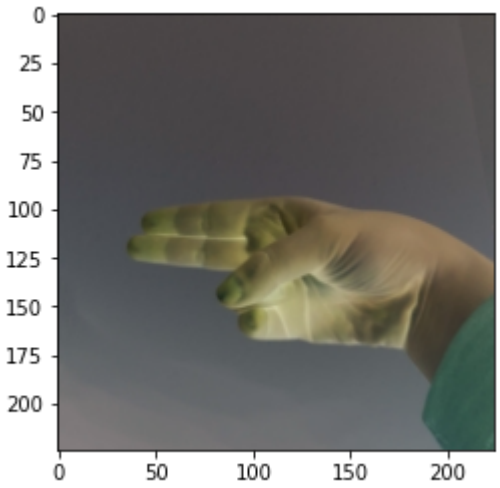



```
Final training accuracy: 0.8393351800554016
Final validation accuracy: 0.6183574879227053
```

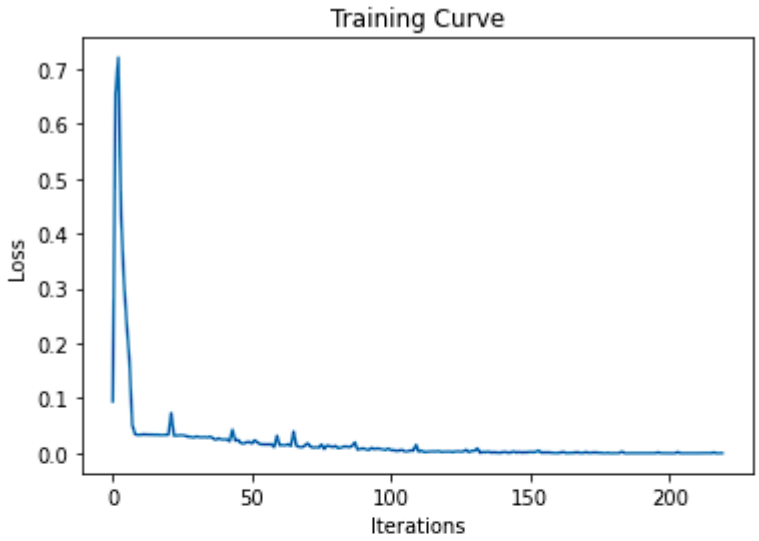
In [18]:
```
# Visualize data to make sure loaders are correct
temp_loader = DataLoader(training_set, batch_size=1, shuffle=True)
transform = torchvision.transforms.ToPILImage()

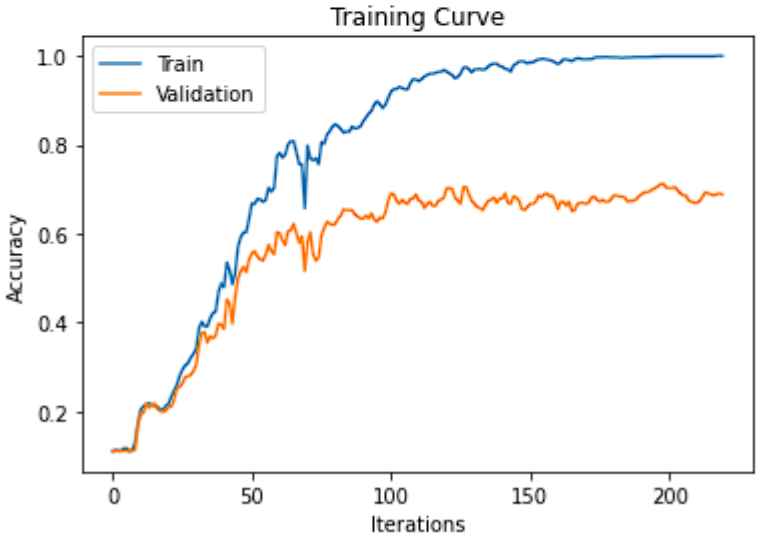
for temp_photo, temp_label in temp_loader:
  print(idx_to_alpha[str(temp_label[0].item())])
  print(temp_photo.squeeze().shape)
  plt.imshow(transform(temp_photo.squeeze()))
  break
```

```
H
torch.Size([3, 224, 224])
```



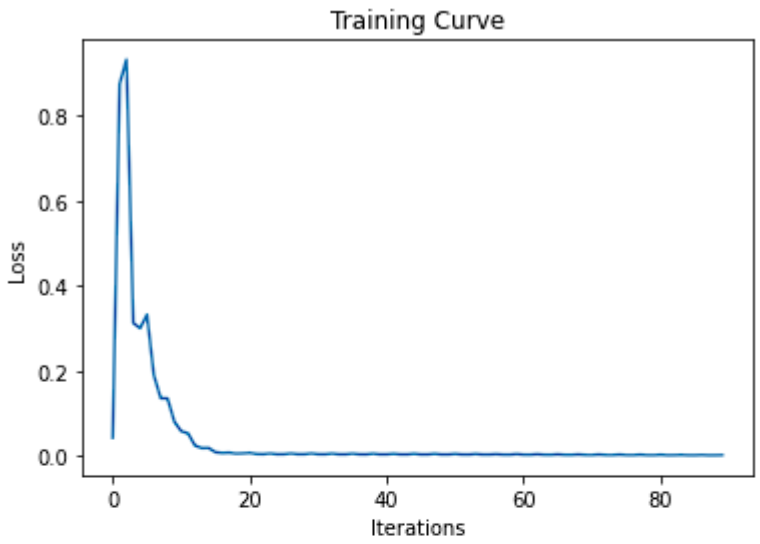
Attempt 1 - 64 batch size, 32 hidden units in ANN, 5 channels for CNN, 10 epochs





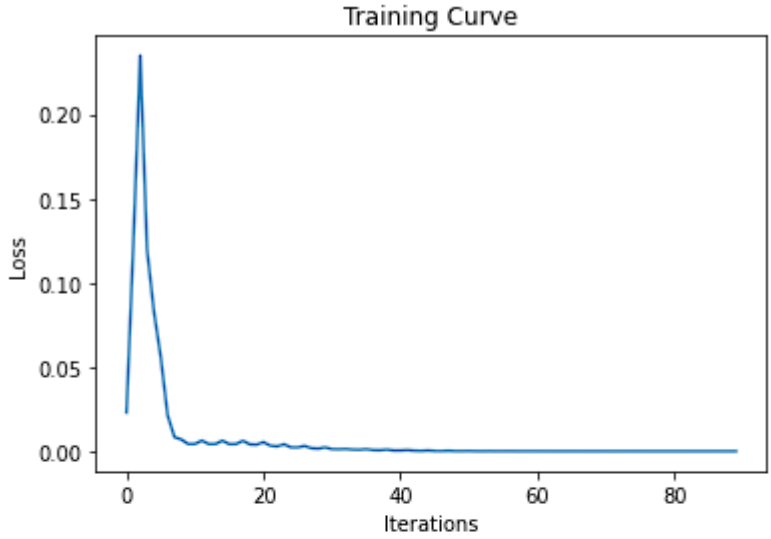

```
Final training accuracy: 0.9992716678805535
Final validation accuracy: 0.6879432624113475
```

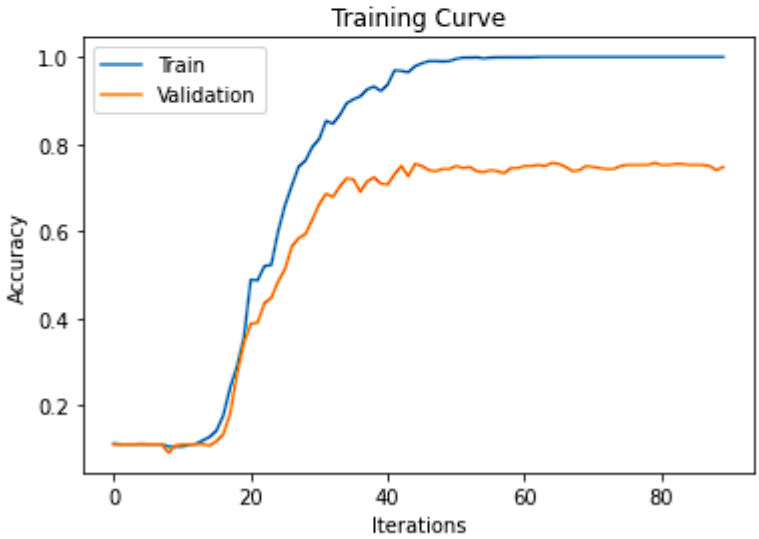
Attempt 2 - 512 batch size, 100 hidden units in ANN, 4 channels for CNN, 30 epochs




```
Final training accuracy: 0.8638018936635106
Final validation accuracy: 0.5650118203309693
```

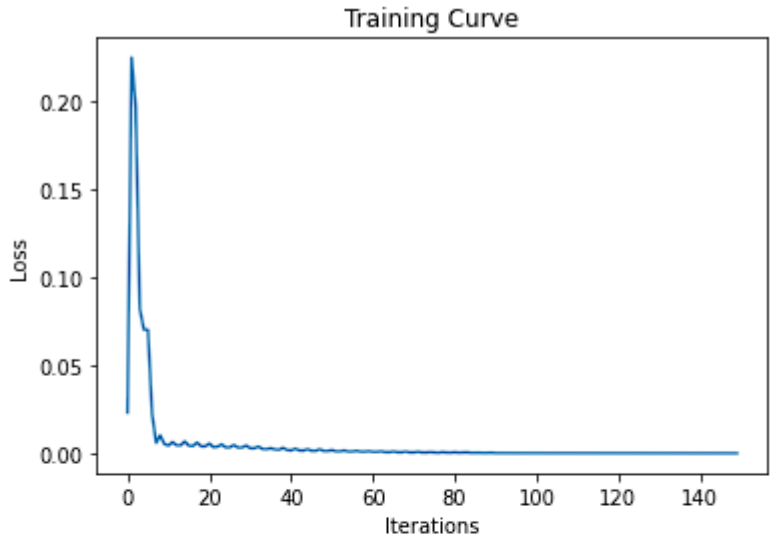
Attempt 3 - 512 batch size, 25 hidden units in ANN, 4 channels for CNN, 30 epochs

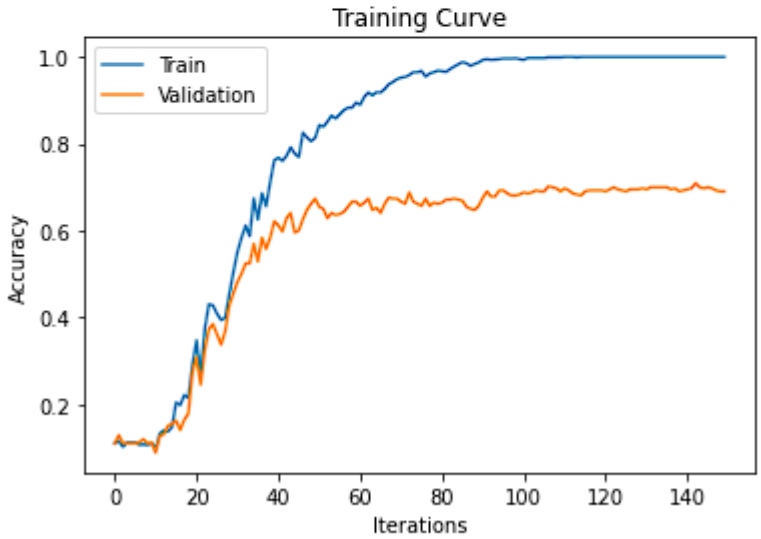





```
Final training accuracy: 0.9992716678805535
Final validation accuracy: 0.7470449172576832
```

Attempt 4 - 512 batch size, 20 hidden units in ANN, 4 channels for CNN, 50 epochs






```
Final training accuracy: 0.9992716678805535
Final validation accuracy: 0.6903073286052009
```

Part (c) - 2 pt

Choose the best model out of all the ones that you have trained. Justify your choice.

Attempt 3 was the best model out of all the trained models because while it's still overfit, it has the highest validation accuracy and is the most likely to do generalize well to unseen examples.

Part (d) - 2 pt

Report the test accuracy of your best model. You should only do this step once and prior to this step you should have only used the training and validation data.

In [10]:
```
best_CNN = CNN()
state = torch.load(f"./CNN_epoch_{'29'}")
best_CNN.load_state_dict(state)
best_CNN.to(device)

params = {
    'batch_size': 128,
    'shuffle': True,
    'num_workers': 1
}
testing_loader = DataLoader(testing_set, **params)

test_acc = calc_acc(best_CNN, testing_loader)
print(f"The test accuracy of the model is {test_acc}")
```

```
The test accuracy of the model is 0.6135265700483091
```

The accuracy of my best model was 0.6891 (attempt 3). (The accuracy above is different because I tried to mess around with some other settings after I tested my best model).

4. Transfer Learning [15 pt]

For many image classification tasks, it is generally not a good idea to train a very large deep neural network model from scratch due to the enormous compute requirements and lack of sufficient amounts of training data.

One of the better options is to try using an existing model that performs a similar task to the one you need to solve. This method of utilizing a pre-trained network for other similar tasks is broadly termed **Transfer Learning**. In this assignment, we will use Transfer Learning to extract features from the hand gesture images. Then, train a smaller network to use these features as input and classify the hand gestures.

As you have learned from the CNN lecture, convolution layers extract various features from the images which get utilized by the fully connected layers for correct classification. AlexNet architecture played a pivotal role in establishing Deep Neural Nets as a go-to tool for image classification problems and we will use an ImageNet pre-trained AlexNet model to extract features in this assignment.

Part (a) - 5 pt

Here is the code to load the AlexNet network, with pretrained weights. When you first run the code, PyTorch will download the pretrained weights from the internet.

In [39]:
```
import torchvision.models
alexnet = torchvision.models.alexnet(pretrained=True)
```

```
/usr/local/lib/python3.8/dist-packages/torchvision/models/_utils.py:208: User
Warning: The parameter 'pretrained' is deprecated since 0.13 and may be remov
ed in the future, please use 'weights' instead.
  warnings.warn(
/usr/local/lib/python3.8/dist-packages/torchvision/models/_utils.py:223: User
Warning: Arguments other than a weight enum or `None` for 'weights' are depre
cated since 0.13 and may be removed in the future. The current behavior is eq
uivalent to passing `weights=AlexNet_Weights.IMAGENET1K_V1`. You can also use
`weights=AlexNet_Weights.DEFAULT` to get the most up-to-date weights.
  warnings.warn(msg)
Downloading: "https://download.pytorch.org/models/alexnet-owt-7be5be79.pth" t
o /root/.cache/torch/hub/checkpoints/alexnet-owt-7be5be79.pth
```

The alexnet model is split up into two components: *alexnet.features* and *alexnet.classifier*. The first neural network component, *alexnet.features*, is used to compute convolutional features, which are taken as input in *alexnet.classifier*.

The neural network alexnet.features expects an image tensor of shape Nx3x224x224 as input and it will output a tensor of shape Nx256x6x6 . (N = batch size).

Compute the AlexNet features for each of your training, validation, and test data. Here is an example code snippet showing how you can compute the AlexNet features for some images (your actual code might be different):

In [ ]:
```
# img = ... a PyTorch tensor with shape [N,3,224,224] containing hand images
...
features = alexnet.features(img)
```

```
---------------------------------------------------------------------------
NameError                                 Traceback (most recent call last)
<ipython-input-53-4be785f3ced5> in <module>
      1 # img = ... a PyTorch tensor with shape [N,3,224,224] containing hand
images ...
----> 2 features = alexnet.features(img)

NameError: name 'img' is not defined
```

Save the computed features. You will be using these features as input to your neural network in Part (b), and you do not want to re-compute the features every time. Instead, run *alexnet.features* once for each image, and save the result.

In [40]:
```
def data_prep_alex(data, type):
  # Change datatype
  data = data.astype(np.float32)

  # Turn into features
  data = alexnet.features(torch.from_numpy(data))

  # Save processed data
  np.save(f"{type}_alexdata.npy", np.array(data.detach(), dtype=np.float32))
```

In [41]:
```
# need to process data individually since not enough ram
data = np.moveaxis(np.load("./training_data.npy"), -1, 1)
data_prep_alex(data[0:data.shape[0]//2], "training1")
data_prep_alex(data[data.shape[0]//2:], "training2")

data = np.moveaxis(np.load("./validation_data.npy"), -1, 1)
data_prep_alex(data, "validation")

data = np.moveaxis(np.load("./testing_data.npy"), -1, 1)
data_prep_alex(data, "testing")
```

Part (b) - 3 pt

Build a convolutional neural network model that takes as input these AlexNet features, and makes a prediction. Your model should be a subclass of nn.Module.

Explain your choice of neural network architecture: how many layers did you choose? What types of layers did you use: fully-connected or convolutional? What about other decisions like pooling layers, activation functions, number of channels / hidden units in each layer?

Here is an example of how your model may be called:

In [ ]:
```
# features = ... load precomputed alexnet.features(img) ...
output = model(features)
prob = F.softmax(output)
```

In [42]:
```
class Classifier(nn.Module):
  def __init__(self):
    super(Classifier, self).__init__()
    self.conv1 = nn.Conv2d(256, 200, 2)
    self.conv2 = nn.Conv2d(200, 300, 2)

    self.pool1 = nn.MaxPool2d(2, 1)
    self.pool2 = nn.MaxPool2d(2, 2)

    self.fc1 = nn.Linear(300*1*1, 50)
    self.fc2 = nn.Linear(50, 9)

  def forward(self, x):
    x = self.pool1(F.relu(self.conv1(x)))
    x = self.pool2(F.relu(self.conv2(x)))

    x = x.view(-1, 300*1*1)
    x = F.relu(self.fc1(x))
    x = self.fc2(x)

    return x
```

I used 2 convolutional layers and 2 fully connected layers because my model above used the same architecture and was able to reasonable capture the relevant features and classify the images correctly. Since AlexNet is way better trained than my model above, using 2 convolutional layers to help tune it a little to the specific task and then 2 fully connected layers to classify the images is likely enough. The number of channels and hidden units was chosen for the same reason.

I chose to use 2 max pooling layers with kernel size 2 and stride of 1 and 2 to cover all the data but ensure the outputted data is large enough to inputted into the classifier.

I used ReLU because ReLU generally works better than functions like sigmoid. A softmax was used in the loss function to classify the data.

Part (c) - 5 pt

Train your new network, including any hyperparameter tuning. Plot and submit the training curve of your best model only.

Note: Depending on how you are caching (saving) your AlexNet features, PyTorch might still be tracking updates to the **AlexNet weights**, which we are not tuning. One workaround is to convert your AlexNet feature tensor into a numpy array, and then back into a PyTorch tensor.

In [ ]:
```
tensor = torch.from_numpy(tensor.detach().numpy())
```

In [43]:
```
# Create datasets
training_features = np.concatenate((np.load("./training1_alexdata.npy"),
                                    np.load("./training2_alexdata.npy")), axis=
0)
validation_features = np.load("./validation_alexdata.npy")

training_labels = np.load("./training_labels.npy")
validation_labels = np.load("./validation_labels.npy")

training_set = Dataset(training_features, training_labels)
validation_set = Dataset(validation_features, validation_labels)

# Create model
alexnet_classifier = Classifier()
alexnet_classifier.to(device)

# Train
train(alexnet_classifier, training_set, validation_set,
      num_epochs=20, batch_size=32)
```

```
Iteration 0, epoch 1
Loss 0.08874219155311585, train accuracy 0.15401662049861495, val accuracy 0.
19806763285024154
Iteration 1, epoch 1
Loss 0.13720484077930450, train accuracy 0.1700831024930748, val accuracy 0.15
458937198067632
Iteration 2, epoch 1
Loss 0.09930010885000229, train accuracy 0.11578947368421053, val accuracy 0.
1111111111111111
Iteration 3, epoch 1
Loss 0.10147774964570999, train accuracy 0.13518005540166206, val accuracy 0.
11594202898550725
Iteration 4, epoch 1
Loss 0.08083362877368927, train accuracy 0.2260387811634349, val accuracy 0.2
560386473429952
Iteration 5, epoch 1
Loss 0.0717010498046875, train accuracy 0.18670360110803325, val accuracy 0.1
4492753623188406
Iteration 6, epoch 1
Loss 0.08252360671758652, train accuracy 0.1811634349030471, val accuracy 0.1
5942028985507245
Iteration 7, epoch 1
Loss 0.06941003352403641, train accuracy 0.26537396121883655, val accuracy 0.
2318840579710145
Iteration 8, epoch 1
Loss 0.06200232356786728, train accuracy 0.3191135734072022, val accuracy 0.2
6570048309178745
Iteration 9, epoch 1
Loss 0.061775192618370056, train accuracy 0.3479224376731302, val accuracy 0.
3285024154589372
Iteration 10, epoch 1
Loss 0.06208435446023941, train accuracy 0.339612188365651, val accuracy 0.32
367149758454106
Iteration 11, epoch 1
Loss 0.05327713489532471, train accuracy 0.3401662049861496, val accuracy 0.2
946859903381642
Iteration 12, epoch 1
Loss 0.060827434062957764, train accuracy 0.24930747922437674, val accuracy
0.2318840579710145
Iteration 13, epoch 1
Loss 0.05791495367884636, train accuracy 0.27479224376731304, val accuracy 0.
2560386473429952
Iteration 14, epoch 1
Loss 0.055225957185029984, train accuracy 0.3894736842105263, val accuracy 0.
38164251207729466
Iteration 15, epoch 1
Loss 0.05105026438832283, train accuracy 0.31357340720221605, val accuracy 0.
32367149758454106
Iteration 16, epoch 1
Loss 0.06794988363981247, train accuracy 0.3922437673130194, val accuracy 0.4
1545893719806765
Iteration 17, epoch 1
Loss 0.05557093396782875, train accuracy 0.46204986149584487, val accuracy 0.
42028985507246375
Iteration 18, epoch 1
Loss 0.053814154118299484, train accuracy 0.4332409972299169, val accuracy 0.
3864734299516908
```

```
Iteration 19, epoch 1
Loss 0.057640157639980316, train accuracy 0.41274238227146814, val accuracy
0.37681159420289856
Iteration 20, epoch 1
Loss 0.04857618361711502, train accuracy 0.45429362880886426, val accuracy 0.
3864734299516908
Iteration 21, epoch 1
Loss 0.0536409430205822, train accuracy 0.5141274238227147, val accuracy 0.42
51207729468599
Iteration 22, epoch 1
Loss 0.05805095285177231, train accuracy 0.535180055401662, val accuracy 0.48
792270531400966
Iteration 23, epoch 1
Loss 0.04764891415834427, train accuracy 0.539612188365651, val accuracy 0.49
27536231884058
Iteration 24, epoch 1
Loss 0.04391617327928543, train accuracy 0.5268698060941829, val accuracy 0.4
7342995169082125
Iteration 25, epoch 1
Loss 0.050997544080019, train accuracy 0.5024930747922438, val accuracy 0.458
93719806763283
Iteration 26, epoch 1
Loss 0.04573769122362137, train accuracy 0.49750692520775625, val accuracy 0.
46859903381642515
Iteration 27, epoch 1
Loss 0.05344963073730469, train accuracy 0.5290858725761773, val accuracy 0.5
024154589371981
Iteration 28, epoch 1
Loss 0.037366848438978195, train accuracy 0.5800554016620498, val accuracy 0.
5362318840579711
Iteration 29, epoch 1
Loss 0.03702284395694733, train accuracy 0.6299168975069253, val accuracy 0.5
603864734299517
Iteration 30, epoch 1
Loss 0.04267343878746033, train accuracy 0.643213296398892, val accuracy 0.59
90338164251208
Iteration 31, epoch 1
Loss 0.038536593317985535, train accuracy 0.6354570637119114, val accuracy 0.
5652173913043478
Iteration 32, epoch 1
Loss 0.040966764092445374, train accuracy 0.650415512465374, val accuracy 0.5
797101449275363
Iteration 33, epoch 1
Loss 0.0403372161090374, train accuracy 0.6808864265927977, val accuracy 0.61
83574879227053
Iteration 34, epoch 1
Loss 0.02239944413304329, train accuracy 0.6908587257617729, val accuracy 0.6
231884057971014
Iteration 35, epoch 1
Loss 0.033918797969818115, train accuracy 0.6559556786703601, val accuracy 0.
6231884057971014
Iteration 36, epoch 1
Loss 0.02970680221915245, train accuracy 0.6204986149584487, val accuracy 0.5
748792270531401
Iteration 37, epoch 1
Loss 0.03899476304650307, train accuracy 0.6454293628808865, val accuracy 0.5
990338164251208
```

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Iteration 38, epoch 1
Loss 0.0286007858812809, train accuracy 0.7063711911357341, val accuracy 0.61
83574879227053
Iteration 39, epoch 1
Loss 0.027557197958230972, train accuracy 0.7096952908587257, val accuracy 0.
6231884057971014
Iteration 40, epoch 1
Loss 0.02920946665108204, train accuracy 0.7135734072022161, val accuracy 0.6
473429951690821
Iteration 41, epoch 1
Loss 0.03646861016750336, train accuracy 0.7224376731301939, val accuracy 0.6
473429951690821
Iteration 42, epoch 1
Loss 0.03190893307328224, train accuracy 0.689196675900277, val accuracy 0.60
86956521739131
Iteration 43, epoch 1
Loss 0.027159791439771652, train accuracy 0.6642659279778393, val accuracy 0.
5845410628019324
Iteration 44, epoch 1
Loss 0.027476314455270767, train accuracy 0.6775623268698061, val accuracy 0.
6231884057971014
Iteration 45, epoch 1
Loss 0.03207659721374512, train accuracy 0.7102493074792243, val accuracy 0.6
376811594202898
Iteration 46, epoch 1
Loss 0.025834908708930016, train accuracy 0.7229916897506925, val accuracy 0.
6328502415458938
Iteration 47, epoch 1
Loss 0.024070059880614 28, train accuracy 0.7130193905817175, val accuracy 0.6
473429951690821
Iteration 48, epoch 1
Loss 0.026714183390140533, train accuracy 0.710803324099723, val accuracy 0.6
135265700483091
Iteration 49, epoch 1
Loss 0.02817782387137413, train accuracy 0.7240997229916898, val accuracy 0.6
328502415458938
Iteration 50, epoch 1
Loss 0.018244190141558647, train accuracy 0.7595567867036012, val accuracy 0.
6763285024154589
Iteration 51, epoch 1
Loss 0.025454949587583542, train accuracy 0.7578947368421053, val accuracy 0.
7198067632850241
Iteration 52, epoch 1
Loss 0.0175028033554554, train accuracy 0.7268698060941828, val accuracy 0.67
63285024154589
Iteration 53, epoch 1
Loss 0.026028120890259743, train accuracy 0.7418282548476455, val accuracy 0.
6811594202898551
Iteration 54, epoch 1
Loss 0.02426263317465782, train accuracy 0.7695290858725762, val accuracy 0.6
666666666666666
Iteration 55, epoch 1
Loss 0.0169543270021677, train accuracy 0.7506925207756233, val accuracy 0.62
80193236714976
Iteration 56, epoch 1
Loss 0.03505814075469971, train accuracy 0.7844875346260388, val accuracy 0.6
618357487922706
```

```
Iteration 57, epoch 2
Loss 0.011874091811478138, train accuracy 0.8110803324099723, val accuracy 0.
6763285024154589
Iteration 58, epoch 2
Loss 0.02404703013598919, train accuracy 0.8060941828254847, val accuracy 0.7
14975845410628
Iteration 59, epoch 2
Loss 0.020184317603707314, train accuracy 0.778393351800554, val accuracy 0.7
342995169082126
Iteration 60, epoch 2
Loss 0.015931952744722366, train accuracy 0.7595567867036012, val accuracy 0.
7004830917874396
Iteration 61, epoch 2
Loss 0.016540996730327606, train accuracy 0.7595567867036012, val accuracy 0.
714975845410628
Iteration 62, epoch 2
Loss 0.010793198831379414, train accuracy 0.7656509695290858, val accuracy 0.
748792270531401
Iteration 63, epoch 2
Loss 0.019751159474253654, train accuracy 0.7950138504155124, val accuracy 0.
7632850241545893
Iteration 64, epoch 2
Loss 0.021320218220353127, train accuracy 0.8354570637119113, val accuracy 0.
7922705314009661
Iteration 65, epoch 2
Loss 0.013284264132380486, train accuracy 0.8592797783933518, val accuracy 0.
7971014492753623
Iteration 66, epoch 2
Loss 0.011641065590083599, train accuracy 0.8332409972299168, val accuracy 0.
7584541062801933
Iteration 67, epoch 2
Loss 0.017952850088477135, train accuracy 0.8204986149584488, val accuracy 0.
7391304347826086
Iteration 68, epoch 2
Loss 0.011038162745535374, train accuracy 0.8260387811634349, val accuracy 0.
748792270531401
Iteration 69, epoch 2
Loss 0.023570669814944267, train accuracy 0.843213296398892, val accuracy 0.7
681159420289855
Iteration 70, epoch 2
Loss 0.019474955275654793, train accuracy 0.8792243767313019, val accuracy 0.
7777777777777778
Iteration 71, epoch 2
Loss 0.015420942567288876, train accuracy 0.8349030470914127, val accuracy 0.
7632850241545893
Iteration 72, epoch 2
Loss 0.019361702725291252, train accuracy 0.7440443213296399, val accuracy 0.
6618357487922706
Iteration 73, epoch 2
Loss 0.019340721890330315, train accuracy 0.7434903047091412, val accuracy 0.
6618357487922706
Iteration 74, epoch 2
Loss 0.027157660573720932, train accuracy 0.8049861495844876, val accuracy 0.
7053140096618358
Iteration 75, epoch 2
Loss 0.014891783706843853, train accuracy 0.8188365650969529, val accuracy 0.
748792270531401
```

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Iteration 76, epoch 2
Loss 0.01757711172103882, train accuracy 0.8321329639889197, val accuracy 0.7
729468599033816
Iteration 77, epoch 2
Loss 0.016207190230488777, train accuracy 0.8177285318559557, val accuracy 0.
7391304347826086
Iteration 78, epoch 2
Loss 0.01036566961556673, train accuracy 0.7872576177285319, val accuracy 0.7
342995169082126
Iteration 79, epoch 2
Loss 0.014623478055000305, train accuracy 0.7573407202216067, val accuracy 0.
7198067632850241
Iteration 80, epoch 2
Loss 0.0339641198515892, train accuracy 0.8121883656509695, val accuracy 0.76
32850241545893
Iteration 81, epoch 2
Loss 0.01776672713458538, train accuracy 0.8592797783933518, val accuracy 0.8
019323671497585
Iteration 82, epoch 2
Loss 0.02074577286839485, train accuracy 0.8808864265927978, val accuracy 0.8
21256038647343
Iteration 83, epoch 2
Loss 0.012726634740829468, train accuracy 0.87202216066482, val accuracy 0.81
15942028985508
Iteration 84, epoch 2
Loss 0.011352546513080597, train accuracy 0.8498614958448754, val accuracy 0.
7681159420289855
Iteration 85, epoch 2
Loss 0.02163277566432953, train accuracy 0.8265927977839335, val accuracy 0.7
391304347826086
Iteration 86, epoch 2
Loss 0.017629962414503098, train accuracy 0.8116343490304709, val accuracy 0.
714975845410628
Iteration 87, epoch 2
Loss 0.024640033021569252, train accuracy 0.8166204986149584, val accuracy 0.
7246376811594203
Iteration 88, epoch 2
Loss 0.02234499156475067, train accuracy 0.845983379501385, val accuracy 0.78
2608695652174
Iteration 89, epoch 2
Loss 0.010846933349967003, train accuracy 0.8637119113573407, val accuracy 0.
8067632850241546
Iteration 90, epoch 2
Loss 0.01587124727666378, train accuracy 0.8692520775623269, val accuracy 0.7
922705314009661
Iteration 91, epoch 2
Loss 0.032745104283094406, train accuracy 0.8714681440443214, val accuracy 0.
8067632850241546
Iteration 92, epoch 2
Loss 0.015347201377153397, train accuracy 0.8681440443213296, val accuracy 0.
7922705314009661
Iteration 93, epoch 2
Loss 0.014728316105902195, train accuracy 0.8742382271468144, val accuracy 0.
8115942028985508
Iteration 94, epoch 2
Loss 0.009590206667780876, train accuracy 0.8653739612188366, val accuracy 0.
821256038647343
```

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Iteration 95, epoch 2
Loss 0.010284901596605778, train accuracy 0.8315789473684211, val accuracy 0.
782608695652174
Iteration 96, epoch 2
Loss 0.019283190369606018, train accuracy 0.8149584487534626, val accuracy 0.
7439613526570048
Iteration 97, epoch 2
Loss 0.026774760335683823, train accuracy 0.7916897506925208, val accuracy 0.
6956521739130435
Iteration 98, epoch 2
Loss 0.015009625814855099, train accuracy 0.7867036011080333, val accuracy 0.
7101449275362319
Iteration 99, epoch 2
Loss 0.029808422550559044, train accuracy 0.8160664819944599, val accuracy 0.
7391304347826086
Iteration 100, epoch 2
Loss 0.022481663152575493, train accuracy 0.8709141274238227, val accuracy 0.
8067632850241546
Iteration 101, epoch 2
Loss 0.012554259970784187, train accuracy 0.9152354570637119, val accuracy 0.
8599033816425121
Iteration 102, epoch 2
Loss 0.005593770649284124, train accuracy 0.9119113573407203, val accuracy 0.
8357487922705314
Iteration 103, epoch 2
Loss 0.014591029845178127, train accuracy 0.8908587257617728, val accuracy 0.
8260869565217391
Iteration 104, epoch 2
Loss 0.012258668430149555, train accuracy 0.8603878116343491, val accuracy 0.
7922705314009661
Iteration 105, epoch 2
Loss 0.011045755818486214, train accuracy 0.8343490304709141, val accuracy 0.
7536231884057971
Iteration 106, epoch 2
Loss 0.02782735601067543, train accuracy 0.8498614958448754, val accuracy 0.7
777777777777778
Iteration 107, epoch 2
Loss 0.014053935185074806, train accuracy 0.8520775623268698, val accuracy 0.
748792270531401
Iteration 108, epoch 2
Loss 0.016513735055923462, train accuracy 0.8426592797783934, val accuracy 0.
7439613526570048
Iteration 109, epoch 2
Loss 0.02132689766585827, train accuracy 0.8554016620498615, val accuracy 0.7
536231884057971
Iteration 110, epoch 2
Loss 0.01278711762279272, train accuracy 0.8725761772853186, val accuracy 0.7
922705314009661
Iteration 111, epoch 2
Loss 0.011508725583553314, train accuracy 0.8803324099722992, val accuracy 0.
8067632850241546
Iteration 112, epoch 2
Loss 0.01601247675716877, train accuracy 0.8803324099722992, val accuracy 0.8
067632850241546
Iteration 113, epoch 2
Loss 0.021430377776806172, train accuracy 0.8764542936288089, val accuracy 0.
8067632850241546
```

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Iteration 114, epoch 3
Loss 0.0076803709380328655, train accuracy 0.867590027700831, val accuracy 0.
8164251207729468
Iteration 115, epoch 3
Loss 0.012002767994999886, train accuracy 0.8598337950138504, val accuracy 0.
8164251207729468
Iteration 116, epoch 3
Loss 0.007446134462952614, train accuracy 0.8587257617728532, val accuracy 0.
8309178743961353
Iteration 117, epoch 3
Loss 0.004941461607813835, train accuracy 0.8603878116343491, val accuracy 0.
8260869565217391
Iteration 118, epoch 3
Loss 0.013242990709841251, train accuracy 0.8775623268698061, val accuracy 0.
8357487922705314
Iteration 119, epoch 3
Loss 0.008514899760484695, train accuracy 0.8947368421052632, val accuracy 0.
8647342995169082
Iteration 120, epoch 3
Loss 0.01159317884594202, train accuracy 0.9069252077562326, val accuracy 0.8
599033816425121
Iteration 121, epoch 3
Loss 0.009120718576014042, train accuracy 0.9074792243767313, val accuracy 0.
8599033816425121
Iteration 122, epoch 3
Loss 0.00945478118956089, train accuracy 0.9124653739612189, val accuracy 0.8
309178743961353
Iteration 123, epoch 3
Loss 0.009358449839055538, train accuracy 0.9224376731301939, val accuracy 0.
8405797101449275
Iteration 124, epoch 3
Loss 0.0018646999960765243, train accuracy 0.9163434903047092, val accuracy
0.8260869565217391
Iteration 125, epoch 3
Loss 0.004768032114952803, train accuracy 0.9058171745152355, val accuracy 0.
8164251207729468
Iteration 126, epoch 3
Loss 0.016138628125190735, train accuracy 0.9047091412742382, val accuracy 0.
8260869565217391
Iteration 127, epoch 3
Loss 0.00460080336779356, train accuracy 0.8975069252077562, val accuracy 0.8
21256038647343
Iteration 128, epoch 3
Loss 0.010967180132865906, train accuracy 0.8975069252077562, val accuracy 0.
8405797101449275
Iteration 129, epoch 3
Loss 0.00846483837813139, train accuracy 0.8991689750692521, val accuracy 0.8
309178743961353
Iteration 130, epoch 3
Loss 0.008076267316937447, train accuracy 0.9091412742382271, val accuracy 0.
8067632850241546
Iteration 131, epoch 3
Loss 0.009359742514789104, train accuracy 0.9185595567867036, val accuracy 0.
821256038647343
Iteration 132, epoch 3
Loss 0.009244127199053764, train accuracy 0.9318559556786704, val accuracy 0.
8405797101449275
```

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Iteration 133, epoch 3
Loss 0.004217281471937895, train accuracy 0.9373961218836565, val accuracy 0.
821256038647343
Iteration 134, epoch 3
Loss 0.01066935621201992, train accuracy 0.9379501385041551, val accuracy 0.8
647342995169082
Iteration 135, epoch 3
Loss 0.012675545178353786, train accuracy 0.9368421052631579, val accuracy 0.
8695652173913043
Iteration 136, epoch 3
Loss 0.009577018208801746, train accuracy 0.9290858725761773, val accuracy 0.
8792270531400966
Iteration 137, epoch 3
Loss 0.006100115366280079, train accuracy 0.9174515235457064, val accuracy 0.
8743961352657005
Iteration 138, epoch 3
Loss 0.008530233055353165, train accuracy 0.9024930747922437, val accuracy 0.
8599033816425121
Iteration 139, epoch 3
Loss 0.006401690188795328, train accuracy 0.9069252077562326, val accuracy 0.
8454106280193237
Iteration 140, epoch 3
Loss 0.005611748434603214, train accuracy 0.9274238227146815, val accuracy 0.
8695652173913043
Iteration 141, epoch 3
Loss 0.006435994524508715, train accuracy 0.9307479224376731, val accuracy 0.
8454106280193237
Iteration 142, epoch 3
Loss 0.00783440750092268, train accuracy 0.932409972299169, val accuracy 0.85
99033816425121
Iteration 143, epoch 3
Loss 0.0034167233388870955, train accuracy 0.9307479224376731, val accuracy
0.8357487922705314
Iteration 144, epoch 3
Loss 0.00769829610362649, train accuracy 0.9290858725761773, val accuracy 0.8
357487922705314
Iteration 145, epoch 3
Loss 0.008636701852083206, train accuracy 0.9362880886426593, val accuracy 0.
8405797101449275
Iteration 146, epoch 3
Loss 0.0103608975186944, train accuracy 0.9401662049861496, val accuracy 0.85
5072463768116
Iteration 147, epoch 3
Loss 0.013892678543925285, train accuracy 0.9540166204986149, val accuracy 0.
855072463768116
Iteration 148, epoch 3
Loss 0.006415293086320162, train accuracy 0.9540166204986149, val accuracy 0.
855072463768116
Iteration 149, epoch 3
Loss 0.0024449576158076525, train accuracy 0.949584487534626, val accuracy 0.
8599033816425121
Iteration 150, epoch 3
Loss 0.011419085785746574, train accuracy 0.9440443213296399, val accuracy 0.
8454106280193237
Iteration 151, epoch 3
Loss 0.009429807774722576, train accuracy 0.9373961218836565, val accuracy 0.
8502415458937198
```

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Iteration 152, epoch 3
Loss 0.007060130592435598, train accuracy 0.9213296398891967, val accuracy 0.
8405797101449275
Iteration 153, epoch 3
Loss 0.003922017756849527, train accuracy 0.8919667590027701, val accuracy 0.
8115942028985508
Iteration 154, epoch 3
Loss 0.010363681241869926, train accuracy 0.8853185595567867, val accuracy 0.
821256038647343
Iteration 155, epoch 3
Loss 0.005950776394456625, train accuracy 0.8864265927977839, val accuracy 0.
8454106280193237
Iteration 156, epoch 3
Loss 0.012037030421197414, train accuracy 0.9246537396121883, val accuracy 0.
8743961352657005
Iteration 157, epoch 3
Loss 0.009816550649702549, train accuracy 0.9606648199445983, val accuracy 0.
8454106280193237
Iteration 158, epoch 3
Loss 0.006729423068463802, train accuracy 0.9601108033240997, val accuracy 0.
8309178743961353
Iteration 159, epoch 3
Loss 0.00896389875560999, train accuracy 0.9401662049861496, val accuracy 0.7
922705314009661
Iteration 160, epoch 3
Loss 0.0035685112234205008, train accuracy 0.9002770083102493, val accuracy
0.7632850241545893
Iteration 161, epoch 3
Loss 0.007049065548926592, train accuracy 0.8908587257617728, val accuracy 0.
7391304347826086
Iteration 162, epoch 3
Loss 0.009354747831821442, train accuracy 0.903601108033241, val accuracy 0.7
439613526570048
Iteration 163, epoch 3
Loss 0.011297171004116535, train accuracy 0.9274238227146815, val accuracy 0.
8067632850241546
Iteration 164, epoch 3
Loss 0.01330071222037077, train accuracy 0.9556786703601108, val accuracy 0.8
502415458937198
Iteration 165, epoch 3
Loss 0.004899569321423769, train accuracy 0.9562326869806094, val accuracy 0.
8792270531400966
Iteration 166, epoch 3
Loss 0.01751650683581829, train accuracy 0.949584487534626, val accuracy 0.86
95652173913043
Iteration 167, epoch 3
Loss 0.004097612574696541, train accuracy 0.9279778393351801, val accuracy 0.
8599033816425121
Iteration 168, epoch 3
Loss 0.011572757735848427, train accuracy 0.9119113573407203, val accuracy 0.
855072463768116
Iteration 169, epoch 3
Loss 0.006969703827053308 5, train accuracy 0.9119113573407203, val accuracy
0.8405797101449275
Iteration 170, epoch 3
Loss 0.032213800228559054, train accuracy 0.913573407202216, val accuracy 0.8
405797101449275
```

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Iteration 171, epoch 4
Loss 0.010611175559461117, train accuracy 0.9019390581717451, val accuracy 0.
8115942028985508
Iteration 172, epoch 4
Loss 0.01676253043115139, train accuracy 0.9074792243767313, val accuracy 0.8
260869565217391
Iteration 173, epoch 4
Loss 0.008543197065591812, train accuracy 0.9052631578947369, val accuracy 0.
8309178743961353
Iteration 174, epoch 4
Loss 0.004419650416821241, train accuracy 0.9013850415512465, val accuracy 0.
8309178743961353
Iteration 175, epoch 4
Loss 0.009164969436824322, train accuracy 0.9058171745152355, val accuracy 0.
8405797101449275
Iteration 176, epoch 4
Loss 0.007314352318644524, train accuracy 0.9329639889196676, val accuracy 0.
8599033816425121
Iteration 177, epoch 4
Loss 0.007267810869961977, train accuracy 0.9457063711911358, val accuracy 0.
8792270531400966
Iteration 178, epoch 4
Loss 0.007395508699119091, train accuracy 0.9418282548476454, val accuracy 0.
8792270531400966
Iteration 179, epoch 4
Loss 0.008618591353297234, train accuracy 0.9313019390581717, val accuracy 0.
855072463768116
Iteration 180, epoch 4
Loss 0.0038651474751532078, train accuracy 0.9185595567867036, val accuracy
0.8405797101449275
Iteration 181, epoch 4
Loss 0.0071077728644013405, train accuracy 0.9052631578947369, val accuracy
0.8260869565217391
Iteration 182, epoch 4
Loss 0.006075010169297457, train accuracy 0.9096952908587258, val accuracy 0.
8164251207729468
Iteration 183, epoch 4
Loss 0.008231277577579021, train accuracy 0.929639889196676, val accuracy 0.8
502415458937198
Iteration 184, epoch 4
Loss 0.011921497993171215, train accuracy 0.9523545706371191, val accuracy 0.
8695652173913043
Iteration 185, epoch 4
Loss 0.002188318409025669, train accuracy 0.9545706371191136, val accuracy 0.
8647342995169082
Iteration 186, epoch 4
Loss 0.004216720350086689, train accuracy 0.9462603878116344, val accuracy 0.
855072463768116
Iteration 187, epoch 4
Loss 0.00802580825984478, train accuracy 0.9362880886426593, val accuracy 0.8
55072463768116
Iteration 188, epoch 4
Loss 0.004488382488489151, train accuracy 0.935180055401662, val accuracy 0.8
405797101449275
Iteration 189, epoch 4
Loss 0.01503164041787386, train accuracy 0.9501385041551247, val accuracy 0.8
695652173913043
```

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Iteration 190, epoch 4
Loss 0.0030456630047410727, train accuracy 0.9601108033240997, val accuracy
0.8840579710144928
Iteration 191, epoch 4
Loss 0.00528687983751297, train accuracy 0.9634349030470915, val accuracy 0.8
985507246376812
Iteration 192, epoch 4
Loss 0.006827733013778925, train accuracy 0.9650969529085872, val accuracy 0.
9178743961352657
Iteration 193, epoch 4
Loss 0.0023588561452925205, train accuracy 0.9578947368421052, val accuracy
0.9033816425120773
Iteration 194, epoch 4
Loss 0.004767285659909248, train accuracy 0.9534626038781163, val accuracy 0.
8888888888888888
Iteration 195, epoch 4
Loss 0.005126709118485451, train accuracy 0.9551246537396122, val accuracy 0.
9033816425120773
Iteration 196, epoch 4
Loss 0.004863962531089783, train accuracy 0.9656509695290859, val accuracy 0.
9178743961352657
Iteration 197, epoch 4
Loss 0.005125238560140133, train accuracy 0.9695290858725761, val accuracy 0.
9130434782608695
Iteration 198, epoch 4
Loss 0.003246924141421914, train accuracy 0.9706371191135734, val accuracy 0.
9082125603864735
Iteration 199, epoch 4
Loss 0.007102315314114094, train accuracy 0.9734072022160665, val accuracy 0.
8888888888888888
Iteration 200, epoch 4
Loss 0.005201720166951418, train accuracy 0.9662049861495845, val accuracy 0.
8888888888888888
Iteration 201, epoch 4
Loss 0.002970062429085374, train accuracy 0.9523545706371191, val accuracy 0.
8647342995169082
Iteration 202, epoch 4
Loss 0.0034245382994413376, train accuracy 0.9484764542936288, val accuracy
0.8357487922705314
Iteration 203, epoch 4
Loss 0.012044462375342846, train accuracy 0.9656509695290859, val accuracy 0.
8743961352657005
Iteration 204, epoch 4
Loss 0.009627625346183777, train accuracy 0.9717451523545706, val accuracy 0.
8888888888888888
Iteration 205, epoch 4
Loss 0.0036652220878750086, train accuracy 0.9601108033240997, val accuracy
0.855072463768116
Iteration 206, epoch 4
Loss 0.002588302828371525, train accuracy 0.9462603878116344, val accuracy 0.
8502415458937198
Iteration 207, epoch 4
Loss 0.003907081671059132, train accuracy 0.9379501385041551, val accuracy 0.
8502415458937198
Iteration 208, epoch 4
Loss 0.01021517813205719, train accuracy 0.9551246537396122, val accuracy 0.8
888888888888888
```

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Iteration 209, epoch 4
Loss 0.008406049571931362, train accuracy 0.9601108033240997, val accuracy 0.
8743961352657005
Iteration 210, epoch 4
Loss 0.0032220615539699793, train accuracy 0.929639889196676, val accuracy 0.
8502415458937198
Iteration 211, epoch 4
Loss 0.006998979952186346, train accuracy 0.8952908587257618, val accuracy 0.
7971014492753623
Iteration 212, epoch 4
Loss 0.009389422833919525, train accuracy 0.9141274238227147, val accuracy 0.
8115942028985508
Iteration 213, epoch 4
Loss 0.0070547000505030155, train accuracy 0.935180055401662, val accuracy 0.
8405797101449275
Iteration 214, epoch 4
Loss 0.0037385534960776567, train accuracy 0.9578947368421052, val accuracy
0.855072463768116
Iteration 215, epoch 4
Loss 0.005374302621930838, train accuracy 0.9678670360110804, val accuracy 0.
8840579710144928
Iteration 216, epoch 4
Loss 0.004422878380864859, train accuracy 0.9601108033240997, val accuracy 0.
8743961352657005
Iteration 217, epoch 4
Loss 0.006482257042080164, train accuracy 0.9556786703601108, val accuracy 0.
855072463768116
Iteration 218, epoch 4
Loss 0.006537470035254955, train accuracy 0.9628808864265928, val accuracy 0.
8743961352657005
Iteration 219, epoch 4
Loss 0.007098570466041565, train accuracy 0.9667590027700831, val accuracy 0.
8888888888888888
Iteration 220, epoch 4
Loss 0.005243824794888496, train accuracy 0.9689750692520775, val accuracy 0.
893719806763285
Iteration 221, epoch 4
Loss 0.003956868313252926, train accuracy 0.961218836565097, val accuracy 0.8
985507246376812
Iteration 222, epoch 4
Loss 0.012072868645191193, train accuracy 0.9490304709141274, val accuracy 0.
893719806763285
Iteration 223, epoch 4
Loss 0.004595366772264242, train accuracy 0.9462603878116344, val accuracy 0.
8985507246376812
Iteration 224, epoch 4
Loss 0.007860945537686348, train accuracy 0.9518005540166204, val accuracy 0.
893719806763285
Iteration 225, epoch 4
Loss 0.005127564538270235, train accuracy 0.942382271468144, val accuracy 0.8
55072463768116
Iteration 226, epoch 4
Loss 0.0039442419074475765, train accuracy 0.9268698060941828, val accuracy
0.8309178743961353
Iteration 227, epoch 4
Loss 0.05019495120415321, train accuracy 0.9445983379501385, val accuracy 0.8
309178743961353
```

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Iteration 228, epoch 5
Loss 0.0016811633249744773, train accuracy 0.9512465373961219, val accuracy
0.8309178743961353
Iteration 229, epoch 5
Loss 0.001959904795512557, train accuracy 0.9479224376731302, val accuracy 0.
8357487922705314
Iteration 230, epoch 5
Loss 0.004987951368093491, train accuracy 0.9462603878116344, val accuracy 0.
8309178743961353
Iteration 231, epoch 5
Loss 0.004617059137672186, train accuracy 0.9578947368421052, val accuracy 0.
855072463768116
Iteration 232, epoch 5
Loss 0.0026259867008775473, train accuracy 0.9656509695290859, val accuracy
0.8599033816425121
Iteration 233, epoch 5
Loss 0.0008349891868419945, train accuracy 0.9634349030470915, val accuracy
0.8743961352657005
Iteration 234, epoch 5
Loss 0.002326574642211199, train accuracy 0.9617728531855956, val accuracy 0.
8888888888888888
Iteration 235, epoch 5
Loss 0.002555253216996789, train accuracy 0.9628808864265928, val accuracy 0.
8985507246376812
Iteration 236, epoch 5
Loss 0.004545432515442371, train accuracy 0.9662049861495845, val accuracy 0.
8888888888888888
Iteration 237, epoch 5
Loss 0.0035275607369840145, train accuracy 0.968421052631579, val accuracy 0.
8985507246376812
Iteration 238, epoch 5
Loss 0.0035391864366829395, train accuracy 0.9634349030470915, val accuracy
0.9082125603864735
Iteration 239, epoch 5
Loss 0.005296757444739342, train accuracy 0.9545706371191136, val accuracy 0.
8792270531400966
Iteration 240, epoch 5
Loss 0.0025067529641091824, train accuracy 0.9440443213296399, val accuracy
0.8599033816425121
Iteration 241, epoch 5
Loss 0.008261649869382381, train accuracy 0.9401662049861496, val accuracy 0.
8502415458937198
Iteration 242, epoch 5
Loss 0.006344926077872515, train accuracy 0.9584487534626038, val accuracy 0.
8792270531400966
Iteration 243, epoch 5
Loss 0.002749450970441103, train accuracy 0.9673130193905817, val accuracy 0.
8888888888888888
Iteration 244, epoch 5
Loss 0.003504026448354125, train accuracy 0.978393351800554, val accuracy 0.9
082125603864735
Iteration 245, epoch 5
Loss 0.0037358941044658422, train accuracy 0.9817174515235457, val accuracy
0.893719806763285
Iteration 246, epoch 5
Loss 0.0026126252487301826, train accuracy 0.968421052631579, val accuracy 0.
8695652173913043
```

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Iteration 247, epoch 5
Loss 0.007876267656683922, train accuracy 0.9540166204986149, val accuracy 0.
8695652173913043
Iteration 248, epoch 5
Loss 0.0021732456516474485, train accuracy 0.9479224376731302, val accuracy
0.8502415458937198
Iteration 249, epoch 5
Loss 0.001926235156133771, train accuracy 0.9412742382271468, val accuracy 0.
8647342995169082
Iteration 250, epoch 5
Loss 0.002865804126486182, train accuracy 0.9457063711911358, val accuracy 0.
8502415458937198
Iteration 251, epoch 5
Loss 0.0022349997889250517, train accuracy 0.9551246537396122, val accuracy
0.8695652173913043
Iteration 252, epoch 5
Loss 0.003540567820891738, train accuracy 0.9700831024930748, val accuracy 0.
8695652173913043
Iteration 253, epoch 5
Loss 0.0013869489775970578, train accuracy 0.9717451523545706, val accuracy
0.8695652173913043
Iteration 254, epoch 5
Loss 0.0037338328547775745, train accuracy 0.9728531855955679, val accuracy
0.8792270531400966
Iteration 255, epoch 5
Loss 0.002817911561578512, train accuracy 0.9717451523545706, val accuracy 0.
8792270531400966
Iteration 256, epoch 5
Loss 0.0031870617531239986, train accuracy 0.9728531855955679, val accuracy
0.8888888888888888
Iteration 257, epoch 5
Loss 0.002012684941291809, train accuracy 0.9750692520775623, val accuracy 0.
893719806763285
Iteration 258, epoch 5
Loss 0.0029370386619120836, train accuracy 0.9806094182825484, val accuracy
0.8985507246376812
Iteration 259, epoch 5
Loss 0.0029691962990909815, train accuracy 0.9878116343490305, val accuracy
0.9082125603864735
Iteration 260, epoch 5
Loss 0.0009646851103752851, train accuracy 0.9867036011080332, val accuracy
0.9130434782608695
Iteration 261, epoch 5
Loss 0.0034224402625113726, train accuracy 0.978393351800554, val accuracy 0.
8985507246376812
Iteration 262, epoch 5
Loss 0.003988703712821007, train accuracy 0.971191135734072, val accuracy 0.8
93719806763285
Iteration 263, epoch 5
Loss 0.0035697787534445524, train accuracy 0.9650969529085872, val accuracy
0.893719806763285
Iteration 264, epoch 5
Loss 0.0032269360963255167, train accuracy 0.9722991689750693, val accuracy
0.9082125603864735
Iteration 265, epoch 5
Loss 0.005199824459850788, train accuracy 0.9822714681440443, val accuracy 0.
9082125603864735
```

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Iteration 266, epoch 5
Loss 0.0021762861870229244, train accuracy 0.9861495844875346, val accuracy
0.9082125603864735
Iteration 267, epoch 5
Loss 0.006251743994653225, train accuracy 0.9833795013850416, val accuracy 0.
8985507246376812
Iteration 268, epoch 5
Loss 0.00038012833101674914, train accuracy 0.9811634349030471, val accuracy
0.8840579710144928
Iteration 269, epoch 5
Loss 0.0021896017715334892, train accuracy 0.9756232686980609, val accuracy
0.8647342995169082
Iteration 270, epoch 5
Loss 0.004605371039360762, train accuracy 0.9695290858725761, val accuracy 0.
8599033816425121
Iteration 271, epoch 5
Loss 0.004240268841385841, train accuracy 0.9673130193905817, val accuracy 0.
8599033816425121
Iteration 272, epoch 5
Loss 0.0049589406698942184, train accuracy 0.9717451523545706, val accuracy
0.8599033816425121
Iteration 273, epoch 5
Loss 0.007021768484264612, train accuracy 0.9839335180055402, val accuracy 0.
8599033816425121
Iteration 274, epoch 5
Loss 0.004146776627749205, train accuracy 0.9878116343490305, val accuracy 0.
8647342995169082
Iteration 275, epoch 5
Loss 0.0019979567732661963, train accuracy 0.990027700831025, val accuracy 0.
8840579710144928
Iteration 276, epoch 5
Loss 0.0013639690587297082, train accuracy 0.9905817174515236, val accuracy
0.8840579710144928
Iteration 277, epoch 5
Loss 0.0009674472967162728, train accuracy 0.9855955678670361, val accuracy
0.8840579710144928
Iteration 278, epoch 5
Loss 0.0018669376149773598, train accuracy 0.9828254847645429, val accuracy
0.8599033816425121
Iteration 279, epoch 5
Loss 0.0028551409486681223, train accuracy 0.9778393351800554, val accuracy
0.8599033816425121
Iteration 280, epoch 5
Loss 0.006926146801561117, train accuracy 0.9739612188365651, val accuracy 0.
8695652173913043
Iteration 281, epoch 5
Loss 0.00644191587343812, train accuracy 0.9700831024930748, val accuracy 0.8
55072463768116
Iteration 282, epoch 5
Loss 0.0007173899793997407, train accuracy 0.9656509695290859, val accuracy
0.855072463768116
Iteration 283, epoch 5
Loss 0.007512716576457024, train accuracy 0.9767313019390582, val accuracy 0.
8743961352657005
Iteration 284, epoch 5
Loss 0.00804815785242961, train accuracy 0.9800554016620499, val accuracy 0.8
888888888888888
```

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Iteration 285, epoch 6
Loss 0.0009211426367983222, train accuracy 0.9745152354570638, val accuracy
0.8695652173913043
Iteration 286, epoch 6
Loss 0.0026565012522041798, train accuracy 0.9789473684210527, val accuracy
0.8840579710144928
Iteration 287, epoch 6
Loss 0.003921525552868843, train accuracy 0.9817174515235457, val accuracy 0.
8792270531400966
Iteration 288, epoch 6
Loss 0.006520361639559269, train accuracy 0.9889196675900277, val accuracy 0.
9033816425120773
Iteration 289, epoch 6
Loss 0.004146232735365629, train accuracy 0.9878116343490305, val accuracy 0.
927536231884058
Iteration 290, epoch 6
Loss 0.0010791942477226257, train accuracy 0.9833795013850416, val accuracy
0.9227053140096618
Iteration 291, epoch 6
Loss 0.0020830866415053606, train accuracy 0.9695290858725761, val accuracy
0.9227053140096618
Iteration 292, epoch 6
Loss 0.0030523529276251793, train accuracy 0.9601108033240997, val accuracy
0.9227053140096618
Iteration 293, epoch 6
Loss 0.0045933835208415985, train accuracy 0.9778393351800554, val accuracy
0.9033816425120773
Iteration 294, epoch 6
Loss 0.0014948995085433125, train accuracy 0.9844875346260388, val accuracy
0.9033816425120773
Iteration 295, epoch 6
Loss 0.002937403041869402, train accuracy 0.9872576177285318, val accuracy 0.
9033816425120773
Iteration 296, epoch 6
Loss 0.0017263868357986212, train accuracy 0.9894736842105263, val accuracy
0.8985507246376812
Iteration 297, epoch 6
Loss 0.0019251599442213774, train accuracy 0.9894736842105263, val accuracy
0.893719806763285
Iteration 298, epoch 6
Loss 0.0010467121610417962, train accuracy 0.9855955678670361, val accuracy
0.8888888888888888
Iteration 299, epoch 6
Loss 0.0012240222422406077, train accuracy 0.9839335180055402, val accuracy
0.8743961352657005
Iteration 300, epoch 6
Loss 0.001117040286771953, train accuracy 0.9822714681440443, val accuracy 0.
8743961352657005
Iteration 301, epoch 6
Loss 0.0005745201488025486, train accuracy 0.9778393351800554, val accuracy
0.8695652173913043
Iteration 302, epoch 6
Loss 0.005151472985744476, train accuracy 0.9861495844875346, val accuracy 0.
8743961352657005
Iteration 303, epoch 6
Loss 0.0019471208797767758, train accuracy 0.9916897506925207, val accuracy
0.8743961352657005
```

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Iteration 304, epoch 6
Loss 0.0011245672358199954, train accuracy 0.9922437673130194, val accuracy
0.8792270531400966
Iteration 305, epoch 6
Loss 0.0008871504105627537, train accuracy 0.9916897506925207, val accuracy
0.893719806763285
Iteration 306, epoch 6
Loss 0.0006998618482612073, train accuracy 0.9883656509695291, val accuracy
0.8888888888888888
Iteration 307, epoch 6
Loss 0.0006752029876224697, train accuracy 0.9844875346260388, val accuracy
0.8888888888888888
Iteration 308, epoch 6
Loss 0.002301941392943263, train accuracy 0.9839335180055402, val accuracy 0.
8743961352657005
Iteration 309, epoch 6
Loss 0.0011464112903922796, train accuracy 0.9844875346260388, val accuracy
0.8792270531400966
Iteration 310, epoch 6
Loss 0.002059506718069315, train accuracy 0.9855955678670361, val accuracy 0.
893719806763285
Iteration 311, epoch 6
Loss 0.0014066953444853425, train accuracy 0.9883656509695291, val accuracy
0.8985507246376812
Iteration 312, epoch 6
Loss 0.0007860970799811184, train accuracy 0.9883656509695291, val accuracy
0.8985507246376812
Iteration 313, epoch 6
Loss 0.002075111959129572, train accuracy 0.9911357340720222, val accuracy 0.
9082125603864735
Iteration 314, epoch 6
Loss 0.0004557038482744246 7, train accuracy 0.9916897506925207, val accuracy
0.9130434782608695
Iteration 315, epoch 6
Loss 0.00197574938647449, train accuracy 0.9905817174515236, val accuracy 0.9
033816425120773
Iteration 316, epoch 6
Loss 0.001383694470860064, train accuracy 0.990027700831025, val accuracy 0.8
93719806763285
Iteration 317, epoch 6
Loss 0.0032886015251278877, train accuracy 0.9878116343490305, val accuracy
0.8792270531400966
Iteration 318, epoch 6
Loss 0.0027590924873948097, train accuracy 0.9855955678670361, val accuracy
0.8792270531400966
Iteration 319, epoch 6
Loss 0.0017494086641818285, train accuracy 0.9833795013850416, val accuracy
0.8792270531400966
Iteration 320, epoch 6
Loss 0.0014846172416582704, train accuracy 0.9833795013850416, val accuracy
0.8792270531400966
Iteration 321, epoch 6
Loss 0.002255887957289815, train accuracy 0.9894736842105263, val accuracy 0.
8840579710144928
Iteration 322, epoch 6
Loss 0.0015290997689589858, train accuracy 0.9939058171745152, val accuracy
0.9227053140096618
```

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Iteration 323, epoch 6
Loss 0.0008747478132136166, train accuracy 0.990027700831025, val accuracy 0.
9227053140096618
Iteration 324, epoch 6
Loss 0.0010893844300881028, train accuracy 0.9894736842105263, val accuracy
0.9130434782608695
Iteration 325, epoch 6
Loss 0.0034596610348671675, train accuracy 0.9878116343490305, val accuracy
0.9130434782608695
Iteration 326, epoch 6
Loss 0.0032308201771229506, train accuracy 0.9916897506925207, val accuracy
0.9082125603864735
Iteration 327, epoch 6
Loss 0.00023066645371727645, train accuracy 0.9911357340720222, val accuracy
0.9082125603864735
Iteration 328, epoch 6
Loss 0.0021274304017424583, train accuracy 0.992797783933518, val accuracy 0.
9082125603864735
Iteration 329, epoch 6
Loss 0.0009224818786606193, train accuracy 0.9922437673130194, val accuracy
0.9033816425120773
Iteration 330, epoch 6
Loss 0.0018870532512664795, train accuracy 0.9939058171745152, val accuracy
0.9033816425120773
Iteration 331, epoch 6
Loss 0.0010558526264503598, train accuracy 0.9944598337950139, val accuracy
0.9033816425120773
Iteration 332, epoch 6
Loss 0.00173635920509696, train accuracy 0.9939058171745152, val accuracy 0.9
130434782608695
Iteration 333, epoch 6
Loss 0.000763143296353519, train accuracy 0.9922437673130194, val accuracy 0.
8985507246376812
Iteration 334, epoch 6
Loss 0.005672945640981197, train accuracy 0.9861495844875346, val accuracy 0.
8792270531400966
Iteration 335, epoch 6
Loss 0.0010448829270899296, train accuracy 0.9800554016620499, val accuracy
0.8695652173913043
Iteration 336, epoch 6
Loss 0.0010954965837299824, train accuracy 0.9800554016620499, val accuracy
0.855072463768116
Iteration 337, epoch 6
Loss 0.005168844014406204, train accuracy 0.990027700831025, val accuracy 0.8
792270531400966
Iteration 338, epoch 6
Loss 0.0006873540696687996, train accuracy 0.9955678670360111, val accuracy
0.8792270531400966
Iteration 339, epoch 6
Loss 0.0009705980191938579, train accuracy 0.9977839335180055, val accuracy
0.9033816425120773
Iteration 340, epoch 6
Loss 0.0009555940050631762, train accuracy 0.997229916897507, val accuracy 0.
8840579710144928
Iteration 341, epoch 6
Loss 9.305595505373696e-06, train accuracy 0.990027700831025, val accuracy 0.
8695652173913043
```

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Iteration 342, epoch 7
Loss 0.00120450125541538, train accuracy 0.9861495844875346, val accuracy 0.8
454106280193237
Iteration 343, epoch 7
Loss 0.0034646543208509684, train accuracy 0.9833795013850416, val accuracy
0.8502415458937198
Iteration 344, epoch 7
Loss 0.0019115129252895713, train accuracy 0.9822714681440443, val accuracy
0.855072463768116
Iteration 345, epoch 7
Loss 0.0012010959908366203, train accuracy 0.9839335180055402, val accuracy
0.8454106280193237
Iteration 346, epoch 7
Loss 0.0005255850846879184, train accuracy 0.9839335180055402, val accuracy
0.8599033816425121
Iteration 347, epoch 7
Loss 0.002284724498167634, train accuracy 0.9883656509695291, val accuracy 0.
8840579710144928
Iteration 348, epoch 7
Loss 0.00234736455604434, train accuracy 0.992797783933518, val accuracy 0.91
78743961352657
Iteration 349, epoch 7
Loss 0.00017147713515441865, train accuracy 0.997229916897507, val accuracy
0.9371980676328503
Iteration 350, epoch 7
Loss 0.0008886084542609751, train accuracy 0.9933518005540166, val accuracy
0.9371980676328503
Iteration 351, epoch 7
Loss 0.001381450449116528, train accuracy 0.9922437673130194, val accuracy 0.
9371980676328503
Iteration 352, epoch 7
Loss 0.002706353785470128, train accuracy 0.9911357340720222, val accuracy 0.
9371980676328503
Iteration 353, epoch 7
Loss 0.0007932769949547946, train accuracy 0.9911357340720222, val accuracy
0.9371980676328503
Iteration 354, epoch 7
Loss 0.0020225909538567066, train accuracy 0.9955678670360111, val accuracy
0.927536231884058
Iteration 355, epoch 7
Loss 0.0011553650256246328, train accuracy 0.9966759002770084, val accuracy
0.9323671497584541
Iteration 356, epoch 7
Loss 0.0009450249490328133, train accuracy 0.997229916897507, val accuracy 0.
9178743961352657
Iteration 357, epoch 7
Loss 0.0002617879945319146, train accuracy 0.9983379501385041, val accuracy
0.9082125603864735
Iteration 358, epoch 7
Loss 0.0005442938418127596, train accuracy 0.997229916897507, val accuracy 0.
9033816425120773
Iteration 359, epoch 7
Loss 0.0005063877324573696, train accuracy 0.9966759002770084, val accuracy
0.8840579710144928
Iteration 360, epoch 7
Loss 0.0005795463803224266, train accuracy 0.9950138504155125, val accuracy
0.8792270531400966
```

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Iteration 361, epoch 7
Loss 0.0021917009726166725, train accuracy 0.9939058171745152, val accuracy
0.8840579710144928
Iteration 362, epoch 7
Loss 0.0016872091218829155, train accuracy 0.9950138504155125, val accuracy
0.8792270531400966
Iteration 363, epoch 7
Loss 0.0006425263127312064, train accuracy 0.9966759002770084, val accuracy
0.8647342995169082
Iteration 364, epoch 7
Loss 0.0005777734913863242, train accuracy 0.997229916897507, val accuracy 0.
8792270531400966
Iteration 365, epoch 7
Loss 0.0004482828080654144 3, train accuracy 0.997229916897507, val accuracy
0.893719806763285
Iteration 366, epoch 7
Loss 0.0013791999081149697, train accuracy 0.997229916897507, val accuracy 0.
893719806763285
Iteration 367, epoch 7
Loss 0.0002846254501491785, train accuracy 0.9977839335180055, val accuracy
0.9033816425120773
Iteration 368, epoch 7
Loss 6.061859312467277e-05, train accuracy 0.9977839335180055, val accuracy
0.8888888888888888
Iteration 369, epoch 7
Loss 0.0008577798726037145, train accuracy 0.9983379501385041, val accuracy
0.893719806763285
Iteration 370, epoch 7
Loss 0.0010468472028151155, train accuracy 0.9977839335180055, val accuracy
0.9082125603864735
Iteration 371, epoch 7
Loss 0.0008462246623821557, train accuracy 0.9966759002770084, val accuracy
0.9178743961352657
Iteration 372, epoch 7
Loss 0.00010544796532485634, train accuracy 0.9955678670360111, val accuracy
0.9130434782608695
Iteration 373, epoch 7
Loss 0.0004761817108374089, train accuracy 0.9955678670360111, val accuracy
0.9082125603864735
Iteration 374, epoch 7
Loss 0.00041693274397403, train accuracy 0.9950138504155125, val accuracy 0.8
93719806763285
Iteration 375, epoch 7
Loss 0.0007841907208785415, train accuracy 0.9922437673130194, val accuracy
0.893719806763285
Iteration 376, epoch 7
Loss 0.0015956815332174301, train accuracy 0.9955678670360111, val accuracy
0.9033816425120773
Iteration 377, epoch 7
Loss 0.0018513996619731188, train accuracy 0.9966759002770084, val accuracy
0.9130434782608695
Iteration 378, epoch 7
Loss 0.0003289839078206569, train accuracy 0.997229916897507, val accuracy 0.
9082125603864735
Iteration 379, epoch 7
Loss 0.0009979044552892447, train accuracy 0.9988919667590028, val accuracy
0.9130434782608695
```

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Iteration 380, epoch 7
Loss 0.0012101097963750362, train accuracy 0.9983379501385041, val accuracy
0.9178743961352657
Iteration 381, epoch 7
Loss 0.00043868948705494404, train accuracy 0.9983379501385041, val accuracy
0.9082125603864735
Iteration 382, epoch 7
Loss 0.0001371981343254447, train accuracy 0.9977839335180055, val accuracy
0.8985507246376812
Iteration 383, epoch 7
Loss 0.000322907289955765, train accuracy 0.9961218836565097, val accuracy 0.
9033816425120773
Iteration 384, epoch 7
Loss 0.0004269671917427331, train accuracy 0.9955678670360111, val accuracy
0.9033816425120773
Iteration 385, epoch 7
Loss 0.00045156446867622435, train accuracy 0.9961218836565097, val accuracy
0.9033816425120773
Iteration 386, epoch 7
Loss 0.000886449939571321, train accuracy 0.9966759002770084, val accuracy 0.
9082125603864735
Iteration 387, epoch 7
Loss 0.0012223776429891586, train accuracy 0.997229916897507, val accuracy 0.
9082125603864735
Iteration 388, epoch 7
Loss 0.000796821026597172, train accuracy 0.9977839335180055, val accuracy 0.
9227053140096618
Iteration 389, epoch 7
Loss 0.004608029033988714, train accuracy 0.9977839335180055, val accuracy 0.
9033816425120773
Iteration 390, epoch 7
Loss 0.0008559231646358967, train accuracy 0.997229916897507, val accuracy 0.
9082125603864735
Iteration 391, epoch 7
Loss 0.0016972941812127829, train accuracy 0.9939058171745152, val accuracy
0.893719806763285
Iteration 392, epoch 7
Loss 6.506816862383857e-05, train accuracy 0.9894736842105263, val accuracy
0.8792270531400966
Iteration 393, epoch 7
Loss 0.0005690980469807982, train accuracy 0.9850415512465374, val accuracy
0.8792270531400966
Iteration 394, epoch 7
Loss 0.0011894101044163108, train accuracy 0.9828254847645429, val accuracy
0.8792270531400966
Iteration 395, epoch 7
Loss 0.00021104916231706738, train accuracy 0.9806094182825484, val accuracy
0.8840579710144928
Iteration 396, epoch 7
Loss 0.0014482183614745736, train accuracy 0.9855955678670361, val accuracy
0.8985507246376812
Iteration 397, epoch 7
Loss 0.0008951792842708528, train accuracy 0.992797783933518, val accuracy 0.
893719806763285
Iteration 398, epoch 7
Loss 1.5164086317571882e-05, train accuracy 0.9944598337950139, val accuracy
0.893719806763285
```

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Iteration 399, epoch 8
Loss 0.0007907522958703339, train accuracy 0.9955678670360111, val accuracy
0.9082125603864735
Iteration 400, epoch 8
Loss 0.0001677127147559076 5, train accuracy 0.9955678670360111, val accuracy
0.9033816425120773
Iteration 401, epoch 8
Loss 0.0004733406822197139, train accuracy 0.9961218836565097, val accuracy
0.9082125603864735
Iteration 402, epoch 8
Loss 0.000468258949695155, train accuracy 0.9966759002770084, val accuracy 0.
9082125603864735
Iteration 403, epoch 8
Loss 0.0002215183776570484, train accuracy 0.992797783933518, val accuracy 0.
9033816425120773
Iteration 404, epoch 8
Loss 0.0012934188125655055, train accuracy 0.9933518005540166, val accuracy
0.8985507246376812
Iteration 405, epoch 8
Loss 0.0002565552422311157, train accuracy 0.9922437673130194, val accuracy
0.8985507246376812
Iteration 406, epoch 8
Loss 0.0011069400934502482, train accuracy 0.9955678670360111, val accuracy
0.9033816425120773
Iteration 407, epoch 8
Loss 4.013237412436865e-05, train accuracy 0.9966759002770084, val accuracy
0.9082125603864735
Iteration 408, epoch 8
Loss 0.0001873885776149109, train accuracy 0.9966759002770084, val accuracy
0.8985507246376812
Iteration 409, epoch 8
Loss 0.0004440547781996429, train accuracy 0.9966759002770084, val accuracy
0.8985507246376812
Iteration 410, epoch 8
Loss 9.57652009674348e-05, train accuracy 0.9966759002770084, val accuracy 0.
893719806763285
Iteration 411, epoch 8
Loss 0.0010528522543609142, train accuracy 0.9977839335180055, val accuracy
0.893719806763285
Iteration 412, epoch 8
Loss 0.0011727899545803666, train accuracy 0.9988919667590028, val accuracy
0.8985507246376812
Iteration 413, epoch 8
Loss 0.00011096586240455508, train accuracy 0.9988919667590028, val accuracy
0.9033816425120773
Iteration 414, epoch 8
Loss 0.0002840154920704663, train accuracy 0.9983379501385041, val accuracy
0.9082125603864735
Iteration 415, epoch 8
Loss 0.0002537065593060106, train accuracy 0.9977839335180055, val accuracy
0.9130434782608695
Iteration 416, epoch 8
Loss 0.0003780906554311514, train accuracy 0.9977839335180055, val accuracy
0.9082125603864735
Iteration 417, epoch 8
Loss 0.0003981259069405496, train accuracy 0.9983379501385041, val accuracy
0.9033816425120773
```

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Iteration 418, epoch 8
Loss 0.0005419618100859225, train accuracy 0.9977839335180055, val accuracy
0.9082125603864735
Iteration 419, epoch 8
Loss 0.00017501106776762754, train accuracy 0.997229916897507, val accuracy
0.9130434782608695
Iteration 420, epoch 8
Loss 0.0003433076199144125, train accuracy 0.997229916897507, val accuracy 0.
9227053140096618
Iteration 421, epoch 8
Loss 0.0001812475675251335, train accuracy 0.997229916897507, val accuracy 0.
9227053140096618
Iteration 422, epoch 8
Loss 0.000350161426467821, train accuracy 0.9977839335180055, val accuracy 0.
9178743961352657
Iteration 423, epoch 8
Loss 0.0010328482603654265, train accuracy 0.9983379501385041, val accuracy
0.9130434782608695
Iteration 424, epoch 8
Loss 0.00016190181486308575, train accuracy 0.9988919667590028, val accuracy
0.9082125603864735
Iteration 425, epoch 8
Loss 5.6867400417104363e-05, train accuracy 0.9988919667590028, val accuracy
0.9178743961352657
Iteration 426, epoch 8
Loss 0.0006629423587583005, train accuracy 0.9988919667590028, val accuracy
0.9178743961352657
Iteration 427, epoch 8
Loss 0.0005321281496435404, train accuracy 0.9994459833795014, val accuracy
0.9323671497584541
Iteration 428, epoch 8
Loss 0.00011422829993534833, train accuracy 0.9994459833795014, val accuracy
0.9227053140096618
Iteration 429, epoch 8
Loss 0.0002128573541995138, train accuracy 0.9994459833795014, val accuracy
0.9227053140096618
Iteration 430, epoch 8
Loss 0.00015011007781140506, train accuracy 0.9994459833795014, val accuracy
0.9178743961352657
Iteration 431, epoch 8
Loss 0.00012178772885818034, train accuracy 0.9994459833795014, val accuracy
0.9033816425120773
Iteration 432, epoch 8
Loss 0.0001900642819236964, train accuracy 0.9994459833795014, val accuracy
0.9033816425120773
Iteration 433, epoch 8
Loss 0.0002072223724098876, train accuracy 0.9994459833795014, val accuracy
0.8985507246376812
Iteration 434, epoch 8
Loss 5.8538640587357804e-05, train accuracy 0.9988919667590028, val accuracy
0.8985507246376812
Iteration 435, epoch 8
Loss 0.0002103591978084296, train accuracy 0.9983379501385041, val accuracy
0.8985507246376812
Iteration 436, epoch 8
Loss 0.0005984136951155961, train accuracy 0.997229916897507, val accuracy 0.
8985507246376812
```

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Iteration 437, epoch 8
Loss 0.0020424826070666313, train accuracy 0.9988919667590028, val accuracy
0.8985507246376812
Iteration 438, epoch 8
Loss 0.00043663717224262655, train accuracy 0.9994459833795014, val accuracy
0.8985507246376812
Iteration 439, epoch 8
Loss 0.000932595576159656, train accuracy 0.9994459833795014, val accuracy 0.
9033816425120773
Iteration 440, epoch 8
Loss 0.00046559289330616593, train accuracy 0.9994459833795014, val accuracy
0.9227053140096618
Iteration 441, epoch 8
Loss 4.7221499698935077e-05, train accuracy 0.9994459833795014, val accuracy
0.927536231884058
Iteration 442, epoch 8
Loss 5.136019171914086e-05, train accuracy 0.9983379501385041, val accuracy
0.927536231884058
Iteration 443, epoch 8
Loss 0.003506685374304652, train accuracy 0.9988919667590028, val accuracy 0.
9130434782608695
Iteration 444, epoch 8
Loss 0.00037852083914913237, train accuracy 0.9988919667590028, val accuracy
0.9130434782608695
Iteration 445, epoch 8
Loss 0.0003770729817915708, train accuracy 0.9988919667590028, val accuracy
0.9130434782608695
Iteration 446, epoch 8
Loss 0.0004494746099226177, train accuracy 0.9988919667590028, val accuracy
0.9227053140096618
Iteration 447, epoch 8
Loss 0.00011924609134439379, train accuracy 0.9988919667590028, val accuracy
0.9178743961352657
Iteration 448, epoch 8
Loss 0.0003903686592821032, train accuracy 0.9988919667590028, val accuracy
0.9178743961352657
Iteration 449, epoch 8
Loss 0.00013775017578154802, train accuracy 0.9983379501385041, val accuracy
0.9178743961352657
Iteration 450, epoch 8
Loss 0.00011027242726413533, train accuracy 0.9977839335180055, val accuracy
0.9178743961352657
Iteration 451, epoch 8
Loss 0.00013882643543183804, train accuracy 0.9977839335180055, val accuracy
0.9323671497584541
Iteration 452, epoch 8
Loss 0.0004520314687397331, train accuracy 0.9983379501385041, val accuracy
0.927536231884058
Iteration 453, epoch 8
Loss 0.002382622566074133, train accuracy 0.9994459833795014, val accuracy 0.
927536231884058
Iteration 454, epoch 8
Loss 0.0003282582329120487, train accuracy 0.9994459833795014, val accuracy
0.9178743961352657
Iteration 455, epoch 8
Loss 0.0008414983749389648, train accuracy 0.9988919667590028, val accuracy
0.9178743961352657
```

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Iteration 456, epoch 9
Loss 0.0002146672341041267, train accuracy 0.9988919667590028, val accuracy
0.9033816425120773
Iteration 457, epoch 9
Loss 0.006585302297025919, train accuracy 0.9944598337950139, val accuracy 0.
8985507246376812
Iteration 458, epoch 9
Loss 9.544508066028357e-05, train accuracy 0.9861495844875346, val accuracy
0.8985507246376812
Iteration 459, epoch 9
Loss 0.0018490421352908015, train accuracy 0.9933518005540166, val accuracy
0.9082125603864735
Iteration 460, epoch 9
Loss 6.39602294540964e-05, train accuracy 0.997229916897507, val accuracy 0.9
082125603864735
Iteration 461, epoch 9
Loss 9.748760930960998e-05, train accuracy 0.9983379501385041, val accuracy
0.9082125603864735
Iteration 462, epoch 9
Loss 0.0001487906847614795, train accuracy 0.9988919667590028, val accuracy
0.9082125603864735
Iteration 463, epoch 9
Loss 0.0002134515671059 4893, train accuracy 0.9977839335180055, val accuracy
0.9082125603864735
Iteration 464, epoch 9
Loss 6.028230563970283e-05, train accuracy 0.997229916897507, val accuracy 0.
9082125603864735
Iteration 465, epoch 9
Loss 0.0006829270860180259, train accuracy 0.9961218836565097, val accuracy
0.9130434782608695
Iteration 466, epoch 9
Loss 1.7283655324717984e-05, train accuracy 0.9950138504155125, val accuracy
0.9082125603864735
Iteration 467, epoch 9
Loss 0.0006059642182663083, train accuracy 0.9939058171745152, val accuracy
0.9082125603864735
Iteration 468, epoch 9
Loss 3.455304977251217e-05, train accuracy 0.992797783933518, val accuracy 0.
9033816425120773
Iteration 469, epoch 9
Loss 0.0001531301677459851, train accuracy 0.992797783933518, val accuracy 0.
9082125603864735
Iteration 470, epoch 9
Loss 0.0035618653055280447, train accuracy 0.9966759002770084, val accuracy
0.9082125603864735
Iteration 471, epoch 9
Loss 0.00020887830760329962, train accuracy 0.9966759002770084, val accuracy
0.9033816425120773
Iteration 472, epoch 9
Loss 0.00020934022904839367, train accuracy 0.9966759002770084, val accuracy
0.9033816425120773
Iteration 473, epoch 9
Loss 0.00026260846061632037, train accuracy 0.990027700831025, val accuracy
0.8888888888888888
Iteration 474, epoch 9
Loss 0.00029459616052918136, train accuracy 0.9878116343490305, val accuracy
0.8792270531400966
```

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Iteration 475, epoch 9
Loss 0.0027679125778377056, train accuracy 0.9867036011080332, val accuracy
0.8840579710144928
Iteration 476, epoch 9
Loss 0.0014912273036316037, train accuracy 0.9911357340720222, val accuracy
0.9033816425120773
Iteration 477, epoch 9
Loss 0.0003688703582156449 6, train accuracy 0.9933518005540166, val accuracy
0.9033816425120773
Iteration 478, epoch 9
Loss 8.219030132750049e-05, train accuracy 0.992797783933518, val accuracy 0.
9033816425120773
Iteration 479, epoch 9
Loss 0.0004561209061648696 7, train accuracy 0.9933518005540166, val accuracy
0.893719806763285
Iteration 480, epoch 9
Loss 0.0001077559645636938 5, train accuracy 0.9922437673130194, val accuracy
0.8840579710144928
Iteration 481, epoch 9
Loss 0.0009641944780014455, train accuracy 0.9922437673130194, val accuracy
0.8888888888888888
Iteration 482, epoch 9
Loss 0.0005216452409513295, train accuracy 0.9905817174515236, val accuracy
0.8888888888888888
Iteration 483, epoch 9
Loss 0.0003604187222663313, train accuracy 0.9905817174515236, val accuracy
0.8888888888888888
Iteration 484, epoch 9
Loss 0.0004399153403937816 6, train accuracy 0.990027700831025, val accuracy
0.8840579710144928
Iteration 485, epoch 9
Loss 0.0009504264453426003, train accuracy 0.990027700831025, val accuracy 0.
8792270531400966
Iteration 486, epoch 9
Loss 0.0005360394716262817, train accuracy 0.990027700831025, val accuracy 0.
8792270531400966
Iteration 487, epoch 9
Loss 0.0025309836491942406, train accuracy 0.9933518005540166, val accuracy
0.8985507246376812
Iteration 488, epoch 9
Loss 0.0001245868916157633, train accuracy 0.9933518005540166, val accuracy
0.8888888888888888
Iteration 489, epoch 9
Loss 0.0008879398228600621, train accuracy 0.9916897506925207, val accuracy
0.893719806763285
Iteration 490, epoch 9
Loss 0.003461951855570078, train accuracy 0.9916897506925207, val accuracy 0.
8888888888888888
Iteration 491, epoch 9
Loss 0.0007299954304471612, train accuracy 0.9922437673130194, val accuracy
0.8985507246376812
Iteration 492, epoch 9
Loss 0.0030618547461926937, train accuracy 0.9878116343490305, val accuracy
0.8792270531400966
Iteration 493, epoch 9
Loss 0.0014137428952381015, train accuracy 0.9795013850415513, val accuracy
0.8695652173913043
```

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Iteration 494, epoch 9
Loss 0.0030651655979454517, train accuracy 0.9756232686980609, val accuracy
0.8792270531400966
Iteration 495, epoch 9
Loss 0.0023844281677156687, train accuracy 0.9628808864265928, val accuracy
0.8695652173913043
Iteration 496, epoch 9
Loss 0.010296963155269623, train accuracy 0.9944598337950139, val accuracy 0.
8985507246376812
Iteration 497, epoch 9
Loss 0.0008813008316792548, train accuracy 0.9961218836565097, val accuracy
0.893719806763285
Iteration 498, epoch 9
Loss 0.00024209044931922108, train accuracy 0.9861495844875346, val accuracy
0.8888888888888888
Iteration 499, epoch 9
Loss 0.011147879995405674, train accuracy 0.9817174515235457, val accuracy 0.
8888888888888888
Iteration 500, epoch 9
Loss 0.004172595217823982, train accuracy 0.9950138504155125, val accuracy 0.
9227053140096618
Iteration 501, epoch 9
Loss 0.00015694351168349385, train accuracy 0.997229916897507, val accuracy
0.9178743961352657
Iteration 502, epoch 9
Loss 0.000397879455704242, train accuracy 0.9966759002770084, val accuracy 0.
9082125603864735
Iteration 503, epoch 9
Loss 0.0006260123918764293, train accuracy 0.997229916897507, val accuracy 0.
8888888888888888
Iteration 504, epoch 9
Loss 0.000542851397767663, train accuracy 0.9966759002770084, val accuracy 0.
8888888888888888
Iteration 505, epoch 9
Loss 0.0006097551668062806, train accuracy 0.9966759002770084, val accuracy
0.8985507246376812
Iteration 506, epoch 9
Loss 0.0008635817212052643, train accuracy 0.9961218836565097, val accuracy
0.9033816425120773
Iteration 507, epoch 9
Loss 0.0004978145007044077, train accuracy 0.9961218836565097, val accuracy
0.9033816425120773
Iteration 508, epoch 9
Loss 0.0013707306934520602, train accuracy 0.9977839335180055, val accuracy
0.9082125603864735
Iteration 509, epoch 9
Loss 0.001423016656190157, train accuracy 0.9966759002770084, val accuracy 0.
9082125603864735
Iteration 510, epoch 9
Loss 0.001005374826490879, train accuracy 0.9966759002770084, val accuracy 0.
9130434782608695
Iteration 511, epoch 9
Loss 0.0003478143480606377, train accuracy 0.9955678670360111, val accuracy
0.9082125603864735
Iteration 512, epoch 9
Loss 0.0013012350178681887, train accuracy 0.9944598337950139, val accuracy
0.8985507246376812
```

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Iteration 513, epoch 10
Loss 0.0015499009750783443, train accuracy 0.9939058171745152, val accuracy
0.9033816425120773
Iteration 514, epoch 10
Loss 0.0014563467120751739, train accuracy 0.9955678670360111, val accuracy
0.9130434782608695
Iteration 515, epoch 10
Loss 0.0011007563443854451, train accuracy 0.9966759002770084, val accuracy
0.9082125603864735
Iteration 516, epoch 10
Loss 0.00018351372273173183, train accuracy 0.997229916897507, val accuracy
0.9227053140096618
Iteration 517, epoch 10
Loss 3.206314431736246e-05, train accuracy 0.997229916897507, val accuracy 0.
9130434782608695
Iteration 518, epoch 10
Loss 0.0005078305839560926, train accuracy 0.9966759002770084, val accuracy
0.9033816425120773
Iteration 519, epoch 10
Loss 0.0003539439057931304, train accuracy 0.9955678670360111, val accuracy
0.8840579710144928
Iteration 520, epoch 10
Loss 0.001044043223373592, train accuracy 0.9950138504155125, val accuracy 0.
8840579710144928
Iteration 521, epoch 10
Loss 0.0008818350615911186, train accuracy 0.9950138504155125, val accuracy
0.8985507246376812
Iteration 522, epoch 10
Loss 0.0006691384478472173, train accuracy 0.9955678670360111, val accuracy
0.9033816425120773
Iteration 523, epoch 10
Loss 0.0004375666903797537, train accuracy 0.9955678670360111, val accuracy
0.9082125603864735
Iteration 524, epoch 10
Loss 0.0008113395306281745, train accuracy 0.9955678670360111, val accuracy
0.9178743961352657
Iteration 525, epoch 10
Loss 0.0006770872278138995, train accuracy 0.9955678670360111, val accuracy
0.9227053140096618
Iteration 526, epoch 10
Loss 0.0003385760064702481, train accuracy 0.9955678670360111, val accuracy
0.9178743961352657
Iteration 527, epoch 10
Loss 0.0011181483278051019, train accuracy 0.9961218836565097, val accuracy
0.927536231884058
Iteration 528, epoch 10
Loss 0.0007921723881736398, train accuracy 0.9955678670360111, val accuracy
0.927536231884058
Iteration 529, epoch 10
Loss 0.0030838046222925186, train accuracy 0.9950138504155125, val accuracy
0.9323671497584541
Iteration 530, epoch 10
Loss 0.0003355076187290251, train accuracy 0.9961218836565097, val accuracy
0.9227053140096618
Iteration 531, epoch 10
Loss 0.00040415755938738585, train accuracy 0.9961218836565097, val accuracy
0.9033816425120773
```

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Iteration 532, epoch 10
Loss 0.0002047962771030143, train accuracy 0.9961218836565097, val accuracy
0.9033816425120773
Iteration 533, epoch 10
Loss 0.000422704586526379, train accuracy 0.9966759002770084, val accuracy 0.
9033816425120773
Iteration 534, epoch 10
Loss 0.0007793522090651095, train accuracy 0.9955678670360111, val accuracy
0.893719806763285
Iteration 535, epoch 10
Loss 0.00018622002971824259, train accuracy 0.9950138504155125, val accuracy
0.8985507246376812
Iteration 536, epoch 10
Loss 0.00010574893531156704, train accuracy 0.992797783933518, val accuracy
0.893719806763285
Iteration 537, epoch 10
Loss 3.9273927541216835e-05, train accuracy 0.9916897506925207, val accuracy
0.8888888888888888
Iteration 538, epoch 10
Loss 0.000294973113341257, train accuracy 0.9889196675900277, val accuracy 0.
8840579710144928
Iteration 539, epoch 10
Loss 0.0017891714815050364, train accuracy 0.9955678670360111, val accuracy
0.9082125603864735
Iteration 540, epoch 10
Loss 9.90408516372554e-05, train accuracy 0.997229916897507, val accuracy 0.9
082125603864735
Iteration 541, epoch 10
Loss 0.007195587735623121, train accuracy 0.9988919667590028, val accuracy 0.
9033816425120773
Iteration 542, epoch 10
Loss 0.0011758053442463279, train accuracy 0.9922437673130194, val accuracy
0.9033816425120773
Iteration 543, epoch 10
Loss 0.00012458980199880898, train accuracy 0.9828254847645429, val accuracy
0.8792270531400966
Iteration 544, epoch 10
Loss 0.0015217342879623175, train accuracy 0.9789473684210527, val accuracy
0.855072463768116
Iteration 545, epoch 10
Loss 0.008976513519883156, train accuracy 0.9772853185595568, val accuracy 0.
8647342995169082
Iteration 546, epoch 10
Loss 0.002302030799910426, train accuracy 0.9861495844875346, val accuracy 0.
8695652173913043
Iteration 547, epoch 10
Loss 0.0002791718870867044, train accuracy 0.9867036011080332, val accuracy
0.8647342995169082
Iteration 548, epoch 10
Loss 0.0020376567263156176, train accuracy 0.9894736842105263, val accuracy
0.8840579710144928
Iteration 549, epoch 10
Loss 0.0005047190352343023, train accuracy 0.9828254847645429, val accuracy
0.8888888888888888
Iteration 550, epoch 10
Loss 0.0031062536872923374, train accuracy 0.9772853185595568, val accuracy
0.8840579710144928
```

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Iteration 551, epoch 10
Loss 0.0018576494185253978, train accuracy 0.971191135734072, val accuracy 0.
8695652173913043
Iteration 552, epoch 10
Loss 0.0030810441821813583, train accuracy 0.9722991689750693, val accuracy
0.8743961352657005
Iteration 553, epoch 10
Loss 0.0030651043634861708, train accuracy 0.9833795013850416, val accuracy
0.8647342995169082
Iteration 554, epoch 10
Loss 0.0030428420286625624, train accuracy 0.9861495844875346, val accuracy
0.8743961352657005
Iteration 555, epoch 10
Loss 0.0032868015114217997, train accuracy 0.9811634349030471, val accuracy
0.8743961352657005
Iteration 556, epoch 10
Loss 0.0016510909190401435, train accuracy 0.9667590027700831, val accuracy
0.8454106280193237
Iteration 557, epoch 10
Loss 0.003770533949136734, train accuracy 0.9689750692520775, val accuracy 0.
8454106280193237
Iteration 558, epoch 10
Loss 0.0013047187821939588, train accuracy 0.9739612188365651, val accuracy
0.8502415458937198
Iteration 559, epoch 10
Loss 0.004733637906610966, train accuracy 0.9883656509695291, val accuracy 0.
8840579710144928
Iteration 560, epoch 10
Loss 0.009985674172639847, train accuracy 0.992797783933518, val accuracy 0.8
888888888888888
Iteration 561, epoch 10
Loss 0.0001869775442173704 5, train accuracy 0.9905817174515236, val accuracy
0.8792270531400966
Iteration 562, epoch 10
Loss 0.0006084858905524015, train accuracy 0.9573407202216067, val accuracy
0.8502415458937198
Iteration 563, epoch 10
Loss 0.0018741703825071454, train accuracy 0.9523545706371191, val accuracy
0.8502415458937198
Iteration 564, epoch 10
Loss 0.013573061674833298, train accuracy 0.9855955678670361, val accuracy 0.
8888888888888888
Iteration 565, epoch 10
Loss 0.0009800053667277098, train accuracy 0.9667590027700831, val accuracy
0.8502415458937198
Iteration 566, epoch 10
Loss 0.001962899463251233, train accuracy 0.9202216066481994, val accuracy 0.
8019323671497585
Iteration 567, epoch 10
Loss 0.0038135398644953966, train accuracy 0.9052631578947369, val accuracy
0.7922705314009661
Iteration 568, epoch 10
Loss 0.001650501973927021, train accuracy 0.896398891966759, val accuracy 0.7
584541062801933
Iteration 569, epoch 10
Loss 0.011552564226664029, train accuracy 0.9207756232686981, val accuracy 0.
7971014492753623
```

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Iteration 570, epoch 11
Loss 0.021918946877121925, train accuracy 0.9601108033240997, val accuracy 0.
8357487922705314
Iteration 571, epoch 11
Loss 0.002330560702830553, train accuracy 0.9484764542936288, val accuracy 0.
821256038647343
Iteration 572, epoch 11
Loss 0.00425063818693161, train accuracy 0.9041551246537396, val accuracy 0.7
971014492753623
Iteration 573, epoch 11
Loss 0.0034229743760079145, train accuracy 0.8753462603878116, val accuracy
0.7777777777777778
Iteration 574, epoch 11
Loss 0.01645722985267639, train accuracy 0.8864265927977839, val accuracy 0.7
681159420289855
Iteration 575, epoch 11
Loss 0.010384674184024334, train accuracy 0.9213296398891967, val accuracy 0.
8067632850241546
Iteration 576, epoch 11
Loss 0.006520685739815235, train accuracy 0.9473684210526315, val accuracy 0.
8502415458937198
Iteration 577, epoch 11
Loss 0.0010004424257203937, train accuracy 0.9529085872576177, val accuracy
0.8502415458937198
Iteration 578, epoch 11
Loss 0.0026277860160917044, train accuracy 0.9313019390581717, val accuracy
0.8164251207729468
Iteration 579, epoch 11
Loss 0.007544692140072584, train accuracy 0.9357340720221606, val accuracy 0.
8357487922705314
Iteration 580, epoch 11
Loss 0.009102470241487026, train accuracy 0.9368421052631579, val accuracy 0.
8164251207729468
Iteration 581, epoch 11
Loss 0.009386396035552025, train accuracy 0.9340720221606649, val accuracy 0.
8164251207729468
Iteration 582, epoch 11
Loss 0.0005662973853759468, train accuracy 0.925207756232687, val accuracy 0.
8019323671497585
Iteration 583, epoch 11
Loss 0.0025925009977072477, train accuracy 0.9085872576177285, val accuracy
0.8115942028985508
Iteration 584, epoch 11
Loss 0.003609156934544444, train accuracy 0.9185595567867036, val accuracy 0.
8115942028985508
Iteration 585, epoch 11
Loss 0.019862383604049683, train accuracy 0.9457063711911358, val accuracy 0.
821256038647343
Iteration 586, epoch 11
Loss 0.004280312452465296, train accuracy 0.9490304709141274, val accuracy 0.
8502415458937198
Iteration 587, epoch 11
Loss 0.0034049723763018847, train accuracy 0.9501385041551247, val accuracy
0.855072463768116
Iteration 588, epoch 11
Loss 0.007069133222103119, train accuracy 0.9628808864265928, val accuracy 0.
8599033816425121
```

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Iteration 589, epoch 11
Loss 0.0006187497056089342, train accuracy 0.9623268698060942, val accuracy
0.8454106280193237
Iteration 590, epoch 11
Loss 0.0019050824921578169, train accuracy 0.9623268698060942, val accuracy
0.8599033816425121
Iteration 591, epoch 11
Loss 0.008853311650454998, train accuracy 0.9523545706371191, val accuracy 0.
8405797101449275
Iteration 592, epoch 11
Loss 0.004049657378345728, train accuracy 0.9368421052631579, val accuracy 0.
8164251207729468
Iteration 593, epoch 11
Loss 0.008260316215455532, train accuracy 0.9141274238227147, val accuracy 0.
7729468599033816
Iteration 594, epoch 11
Loss 0.010768411681056023, train accuracy 0.8925207756232687, val accuracy 0.
7729468599033816
Iteration 595, epoch 11
Loss 0.005829526111483574, train accuracy 0.8980609418282548, val accuracy 0.
782608695652174
Iteration 596, epoch 11
Loss 0.004034896846860647, train accuracy 0.9318559556786704, val accuracy 0.
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Iteration 597, epoch 11
Loss 0.005001159384846687, train accuracy 0.9722991689750693, val accuracy 0.
821256038647343
Iteration 598, epoch 11
Loss 0.001449749106541276, train accuracy 0.9761772853185595, val accuracy 0.
8502415458937198
Iteration 599, epoch 11
Loss 0.002580919535830617, train accuracy 0.9728531855955679, val accuracy 0.
8405797101449275
Iteration 600, epoch 11
Loss 0.002055797027423978, train accuracy 0.9678670360110804, val accuracy 0.
8309178743961353
Iteration 601, epoch 11
Loss 0.010757901705801487, train accuracy 0.9689750692520775, val accuracy 0.
8405797101449275
Iteration 602, epoch 11
Loss 0.004128502681851387, train accuracy 0.9772853185595568, val accuracy 0.
8743961352657005
Iteration 603, epoch 11
Loss 0.0027194544672966003, train accuracy 0.9811634349030471, val accuracy
0.8840579710144928
Iteration 604, epoch 11
Loss 0.004522568080574274, train accuracy 0.9855955678670361, val accuracy 0.
8985507246376812
Iteration 605, epoch 11
Loss 0.005188274662941694, train accuracy 0.9844875346260388, val accuracy 0.
9033816425120773
Iteration 606, epoch 11
Loss 0.0014485353603959084, train accuracy 0.9745152354570638, val accuracy
0.9033816425120773
Iteration 607, epoch 11
Loss 0.003207997651770711, train accuracy 0.9745152354570638, val accuracy 0.
9033816425120773
```

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Iteration 608, epoch 11
Loss 0.003536117495968938, train accuracy 0.9734072022160665, val accuracy 0.
9033816425120773
Iteration 609, epoch 11
Loss 0.0006938884616829455, train accuracy 0.96398891966759, val accuracy 0.8
93719806763285
Iteration 610, epoch 11
Loss 0.009810893796384335, train accuracy 0.9628808864265928, val accuracy 0.
893719806763285
Iteration 611, epoch 11
Loss 0.0018060081638395786, train accuracy 0.9529085872576177, val accuracy
0.8743961352657005
Iteration 612, epoch 11
Loss 0.010110016912221909, train accuracy 0.9717451523545706, val accuracy 0.
8502415458937198
Iteration 613, epoch 11
Loss 0.0011916359653696418, train accuracy 0.961218836565097, val accuracy 0.
8405797101449275
Iteration 614, epoch 11
Loss 0.002651129849255085, train accuracy 0.9634349030470915, val accuracy 0.
8502415458937198
Iteration 615, epoch 11
Loss 0.002973024034872651, train accuracy 0.9645429362880886, val accuracy 0.
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Iteration 616, epoch 11
Loss 0.00076176697621122, train accuracy 0.9573407202216067, val accuracy 0.8
454106280193237
Iteration 617, epoch 11
Loss 0.006046486087143421, train accuracy 0.9573407202216067, val accuracy 0.
8357487922705314
Iteration 618, epoch 11
Loss 0.001943329581990838, train accuracy 0.9645429362880886, val accuracy 0.
8502415458937198
Iteration 619, epoch 11
Loss 0.003734070807695389, train accuracy 0.9833795013850416, val accuracy 0.
8647342995169082
Iteration 620, epoch 11
Loss 0.0010757931740954518, train accuracy 0.9916897506925207, val accuracy
0.9082125603864735
Iteration 621, epoch 11
Loss 0.0005444907583296299, train accuracy 0.9922437673130194, val accuracy
0.9227053140096618
Iteration 622, epoch 11
Loss 0.001112167607061565, train accuracy 0.990027700831025, val accuracy 0.9
178743961352657
Iteration 623, epoch 11
Loss 0.0009030828368850052, train accuracy 0.9839335180055402, val accuracy
0.9082125603864735
Iteration 624, epoch 11
Loss 0.002027146751061082, train accuracy 0.9767313019390582, val accuracy 0.
8985507246376812
Iteration 625, epoch 11
Loss 0.003892191918566823, train accuracy 0.9750692520775623, val accuracy 0.
893719806763285
Iteration 626, epoch 11
Loss 0.004658054273862105, train accuracy 0.9728531855955679, val accuracy 0.
8840579710144928
```

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Iteration 627, epoch 12
Loss 0.0023352880962193012, train accuracy 0.9806094182825484, val accuracy
0.8985507246376812
Iteration 628, epoch 12
Loss 0.0029745646752417088, train accuracy 0.9889196675900277, val accuracy
0.9082125603864735
Iteration 629, epoch 12
Loss 0.001073644612915814, train accuracy 0.9933518005540166, val accuracy 0.
9033816425120773
Iteration 630, epoch 12
Loss 0.002221357775852084, train accuracy 0.992797783933518, val accuracy 0.9
033816425120773
Iteration 631, epoch 12
Loss 0.0003822079161182046, train accuracy 0.9878116343490305, val accuracy
0.8985507246376812
Iteration 632, epoch 12
Loss 0.0006707991706207395, train accuracy 0.9822714681440443, val accuracy
0.893719806763285
Iteration 633, epoch 12
Loss 0.001272842870093882, train accuracy 0.9795013850415513, val accuracy 0.
8888888888888888
Iteration 634, epoch 12
Loss 0.0011768800904974341, train accuracy 0.9833795013850416, val accuracy
0.8985507246376812
Iteration 635, epoch 12
Loss 0.002065813634544611, train accuracy 0.9833795013850416, val accuracy 0.
9033816425120773
Iteration 636, epoch 12
Loss 0.002006760099902749, train accuracy 0.9867036011080332, val accuracy 0.
8888888888888888
Iteration 637, epoch 12
Loss 0.0003307424194645136 6, train accuracy 0.9861495844875346, val accuracy
0.8888888888888888
Iteration 638, epoch 12
Loss 0.0010872348211705685, train accuracy 0.9789473684210527, val accuracy
0.8888888888888888
Iteration 639, epoch 12
Loss 0.000726899306755513, train accuracy 0.971191135734072, val accuracy 0.8
792270531400966
Iteration 640, epoch 12
Loss 0.0045334347523748875, train accuracy 0.9828254847645429, val accuracy
0.8985507246376812
Iteration 641, epoch 12
Loss 0.0006197065813466907, train accuracy 0.9861495844875346, val accuracy
0.9033816425120773
Iteration 642, epoch 12
Loss 0.0005674907588399947, train accuracy 0.9905817174515236, val accuracy
0.8985507246376812
Iteration 643, epoch 12
Loss 0.0015774037456139922, train accuracy 0.9911357340720222, val accuracy
0.9130434782608695
Iteration 644, epoch 12
Loss 9.878007404040545e-05, train accuracy 0.9867036011080332, val accuracy
0.893719806763285
Iteration 645, epoch 12
Loss 0.0021218599285930395, train accuracy 0.9800554016620499, val accuracy
0.8792270531400966
```

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Iteration 646, epoch 12
Loss 0.002546171424910426, train accuracy 0.9789473684210527, val accuracy 0.
8840579710144928
Iteration 647, epoch 12
Loss 0.0033895238302648067, train accuracy 0.9811634349030471, val accuracy
0.8888888888888888
Iteration 648, epoch 12
Loss 0.003689547535032034, train accuracy 0.9889196675900277, val accuracy 0.
9082125603864735
Iteration 649, epoch 12
Loss 0.00024957204004749656, train accuracy 0.9878116343490305, val accuracy
0.9082125603864735
Iteration 650, epoch 12
Loss 0.012745757587254047, train accuracy 0.990027700831025, val accuracy 0.9
130434782608695
Iteration 651, epoch 12
Loss 0.0025074942968785763, train accuracy 0.9894736842105263, val accuracy
0.8743961352657005
Iteration 652, epoch 12
Loss 0.0006870938232168555, train accuracy 0.9822714681440443, val accuracy
0.8647342995169082
Iteration 653, epoch 12
Loss 0.0007119965739548206, train accuracy 0.9689750692520775, val accuracy
0.8454106280193237
Iteration 654, epoch 12
Loss 0.0009108399390242994, train accuracy 0.9595567867036011, val accuracy
0.8164251207729468
Iteration 655, epoch 12
Loss 0.0009946173522621393, train accuracy 0.9590027700831025, val accuracy
0.821256038647343
Iteration 656, epoch 12
Loss 0.0013087395345792174, train accuracy 0.9623268698060942, val accuracy
0.821256038647343
Iteration 657, epoch 12
Loss 0.0005139052518643439, train accuracy 0.9645429362880886, val accuracy
0.8260869565217391
Iteration 658, epoch 12
Loss 0.0003597479371819645, train accuracy 0.968421052631579, val accuracy 0.
8405797101449275
Iteration 659, epoch 12
Loss 0.001609888975508511, train accuracy 0.9817174515235457, val accuracy 0.
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Iteration 660, epoch 12
Loss 0.002341822488233447, train accuracy 0.9922437673130194, val accuracy 0.
8985507246376812
Iteration 661, epoch 12
Loss 0.00041141518158838153, train accuracy 0.9961218836565097, val accuracy
0.9033816425120773
Iteration 662, epoch 12
Loss 0.0012951937969774008, train accuracy 0.9955678670360111, val accuracy
0.9033816425120773
Iteration 663, epoch 12
Loss 0.00038584909634664655, train accuracy 0.9933518005540166, val accuracy
0.8840579710144928
Iteration 664, epoch 12
Loss 0.0001868786494014784 7, train accuracy 0.9817174515235457, val accuracy
0.8743961352657005
```

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Iteration 665, epoch 12
Loss 0.0013621756806969643, train accuracy 0.9761772853185595, val accuracy
0.8743961352657005
Iteration 666, epoch 12
Loss 0.0009822752326726913, train accuracy 0.9795013850415513, val accuracy
0.8647342995169082
Iteration 667, epoch 12
Loss 0.0003511417016852647, train accuracy 0.9817174515235457, val accuracy
0.8695652173913043
Iteration 668, epoch 12
Loss 0.005797958001494408, train accuracy 0.9905817174515236, val accuracy 0.
8792270531400966
Iteration 669, epoch 12
Loss 0.00032873282907530665, train accuracy 0.9911357340720222, val accuracy
0.8840579710144928
Iteration 670, epoch 12
Loss 0.0011778182815760374, train accuracy 0.9828254847645429, val accuracy
0.8743961352657005
Iteration 671, epoch 12
Loss 0.0036064127925783396, train accuracy 0.9706371191135734, val accuracy
0.8599033816425121
Iteration 672, epoch 12
Loss 0.0016679854597896338, train accuracy 0.9745152354570638, val accuracy
0.8599033816425121
Iteration 673, epoch 12
Loss 0.00018082837050314993, train accuracy 0.9750692520775623, val accuracy
0.8599033816425121
Iteration 674, epoch 12
Loss 0.006816426757723093, train accuracy 0.9850415512465374, val accuracy 0.
8599033816425121
Iteration 675, epoch 12
Loss 0.00014206267951522022, train accuracy 0.9889196675900277, val accuracy
0.8695652173913043
Iteration 676, epoch 12
Loss 0.009240580722689629, train accuracy 0.9950138504155125, val accuracy 0.
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Iteration 677, epoch 12
Loss 0.0008866412099450827, train accuracy 0.9872576177285318, val accuracy
0.893719806763285
Iteration 678, epoch 12
Loss 0.0015628703404217958, train accuracy 0.9822714681440443, val accuracy
0.8985507246376812
Iteration 679, epoch 12
Loss 0.0022315355017781258, train accuracy 0.978393351800554, val accuracy 0.
893719806763285
Iteration 680, epoch 12
Loss 0.0031467932276427746, train accuracy 0.978393351800554, val accuracy 0.
8985507246376812
Iteration 681, epoch 12
Loss 0.0031154719181358814, train accuracy 0.9772853185595568, val accuracy
0.8985507246376812
Iteration 682, epoch 12
Loss 0.007163968402892351, train accuracy 0.9872576177285318, val accuracy 0.
893719806763285
Iteration 683, epoch 12
Loss 0.0014363292318124038, train accuracy 0.990027700831025, val accuracy 0.
9033816425120773
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Iteration 684, epoch 13
Loss 0.0014781797071918845, train accuracy 0.9933518005540166, val accuracy
0.8985507246376812
Iteration 685, epoch 13
Loss 0.0007847712840884924, train accuracy 0.9939058171745152, val accuracy
0.9082125603864735
Iteration 686, epoch 13
Loss 0.00029167538741603494, train accuracy 0.9944598337950139, val accuracy
0.9227053140096618
Iteration 687, epoch 13
Loss 0.0001289195497520268, train accuracy 0.9933518005540166, val accuracy
0.9227053140096618
Iteration 688, epoch 13
Loss 0.00019854393030982465, train accuracy 0.9911357340720222, val accuracy
0.927536231884058
Iteration 689, epoch 13
Loss 0.0005978283588774502, train accuracy 0.9911357340720222, val accuracy
0.9371980676328503
Iteration 690, epoch 13
Loss 0.002529611112549901, train accuracy 0.990027700831025, val accuracy 0.9
227053140096618
Iteration 691, epoch 13
Loss 0.0003010048239957541, train accuracy 0.9905817174515236, val accuracy
0.9227053140096618
Iteration 692, epoch 13
Loss 0.0016602380201220512, train accuracy 0.9905817174515236, val accuracy
0.9082125603864735
Iteration 693, epoch 13
Loss 9.432629303773865e-05, train accuracy 0.9889196675900277, val accuracy
0.9082125603864735
Iteration 694, epoch 13
Loss 0.0020335610024631023, train accuracy 0.9894736842105263, val accuracy
0.9033816425120773
Iteration 695, epoch 13
Loss 0.0003885532496497035, train accuracy 0.9894736842105263, val accuracy
0.893719806763285
Iteration 696, epoch 13
Loss 0.00038853901787661016, train accuracy 0.9905817174515236, val accuracy
0.8985507246376812
Iteration 697, epoch 13
Loss 0.000580142077524215, train accuracy 0.990027700831025, val accuracy 0.8
985507246376812
Iteration 698, epoch 13
Loss 0.0002606504422146827, train accuracy 0.990027700831025, val accuracy 0.
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Iteration 699, epoch 13
Loss 0.0001870419946499169, train accuracy 0.9905817174515236, val accuracy
0.8985507246376812
Iteration 700, epoch 13
Loss 0.0017675444250926375, train accuracy 0.992797783933518, val accuracy 0.
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Iteration 701, epoch 13
Loss 0.0007129934965632856, train accuracy 0.9939058171745152, val accuracy
0.9082125603864735
Iteration 702, epoch 13
Loss 0.0029069706797599792, train accuracy 0.9922437673130194, val accuracy
0.9130434782608695
```

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Iteration 703, epoch 13
Loss 0.0001565755228511989, train accuracy 0.9822714681440443, val accuracy
0.9082125603864735
Iteration 704, epoch 13
Loss 0.0008903599227778614, train accuracy 0.9745152354570638, val accuracy
0.8985507246376812
Iteration 705, epoch 13
Loss 0.007018644828349352, train accuracy 0.9855955678670361, val accuracy 0.
9082125603864735
Iteration 706, epoch 13
Loss 0.003914159722626209, train accuracy 0.9933518005540166, val accuracy 0.
9130434782608695
Iteration 707, epoch 13
Loss 5.746001988882199e-05, train accuracy 0.9916897506925207, val accuracy
0.8888888888888888
Iteration 708, epoch 13
Loss 8.255904685938731e-05, train accuracy 0.9822714681440443, val accuracy
0.8743961352657005
Iteration 709, epoch 13
Loss 0.0006942476611584425, train accuracy 0.9689750692520775, val accuracy
0.855072463768116
Iteration 710, epoch 13
Loss 0.0020457443315535784, train accuracy 0.9523545706371191, val accuracy
0.8357487922705314
Iteration 711, epoch 13
Loss 0.009591630659997463, train accuracy 0.9772853185595568, val accuracy 0.
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Iteration 712, epoch 13
Loss 0.0014093401841819286, train accuracy 0.990027700831025, val accuracy 0.
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Iteration 713, epoch 13
Loss 0.0014829236315563321, train accuracy 0.992797783933518, val accuracy 0.
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Iteration 714, epoch 13
Loss 0.000912540010176599, train accuracy 0.9905817174515236, val accuracy 0.
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Iteration 715, epoch 13
Loss 0.002184550743550062, train accuracy 0.9789473684210527, val accuracy 0.
893719806763285
Iteration 716, epoch 13
Loss 0.00025116759934462607, train accuracy 0.961218836565097, val accuracy
0.8695652173913043
Iteration 717, epoch 13
Loss 0.000572057964745909, train accuracy 0.9357340720221606, val accuracy 0.
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Iteration 718, epoch 13
Loss 0.00114699627738446, train accuracy 0.9063711911357341, val accuracy 0.8
309178743961353
Iteration 719, epoch 13
Loss 0.010925907641649246, train accuracy 0.971191135734072, val accuracy 0.8
695652173913043
Iteration 720, epoch 13
Loss 0.0010965759865939617, train accuracy 0.9872576177285318, val accuracy
0.8840579710144928
Iteration 721, epoch 13
Loss 0.0005745452945120633, train accuracy 0.9828254847645429, val accuracy
0.893719806763285
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Iteration 722, epoch 13
Loss 0.0018351159524172544, train accuracy 0.9584487534626038, val accuracy
0.8405797101449275
Iteration 723, epoch 13
Loss 0.0006081736064516008, train accuracy 0.9290858725761773, val accuracy
0.8357487922705314
Iteration 724, epoch 13
Loss 0.0036787979770451784, train accuracy 0.9207756232686981, val accuracy
0.8454106280193237
Iteration 725, epoch 13
Loss 0.02134292759001255, train accuracy 0.9506925207756233, val accuracy 0.8
502415458937198
Iteration 726, epoch 13
Loss 0.009794170968234539, train accuracy 0.9806094182825484, val accuracy 0.
893719806763285
Iteration 727, epoch 13
Loss 0.009201300330460072, train accuracy 0.990027700831025, val accuracy 0.9
082125603864735
Iteration 728, epoch 13
Loss 0.0014534478541463614, train accuracy 0.9695290858725761, val accuracy
0.8840579710144928
Iteration 729, epoch 13
Loss 0.004953586962074041, train accuracy 0.9379501385041551, val accuracy 0.
8405797101449275
Iteration 730, epoch 13
Loss 0.010561064817011356, train accuracy 0.9368421052631579, val accuracy 0.
8260869565217391
Iteration 731, epoch 13
Loss 0.014701182022690773, train accuracy 0.9534626038781163, val accuracy 0.
8309178743961353
Iteration 732, epoch 13
Loss 0.010106011293828487, train accuracy 0.9440443213296399, val accuracy 0.
8067632850241546
Iteration 733, epoch 13
Loss 0.004450705833733082, train accuracy 0.9218836565096953, val accuracy 0.
7777777777777778
Iteration 734, epoch 13
Loss 0.004577937535941601, train accuracy 0.925207756232687, val accuracy 0.7
874396135265701
Iteration 735, epoch 13
Loss 0.018138835206627846, train accuracy 0.9379501385041551, val accuracy 0.
8164251207729468
Iteration 736, epoch 13
Loss 0.0006627109833061695, train accuracy 0.9468144044321329, val accuracy
0.8454106280193237
Iteration 737, epoch 13
Loss 0.004506987053900957, train accuracy 0.9667590027700831, val accuracy 0.
8647342995169082
Iteration 738, epoch 13
Loss 0.0006418925477191806, train accuracy 0.978393351800554, val accuracy 0.
8888888888888888
Iteration 739, epoch 13
Loss 0.00515333516523242, train accuracy 0.9861495844875346, val accuracy 0.9
082125603864735
Iteration 740, epoch 13
Loss 0.0064028644791016215, train accuracy 0.9822714681440443, val accuracy
0.9082125603864735
```

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Iteration 741, epoch 14
Loss 0.0038698853459209204, train accuracy 0.9745152354570638, val accuracy
0.8840579710144928
Iteration 742, epoch 14
Loss 0.0030614088755100965, train accuracy 0.9601108033240997, val accuracy
0.8502415458937198
Iteration 743, epoch 14
Loss 0.00615026755258441, train accuracy 0.9490304709141274, val accuracy 0.8
405797101449275
Iteration 744, epoch 14
Loss 0.0019881506450474262, train accuracy 0.9473684210526315, val accuracy
0.8309178743961353
Iteration 745, epoch 14
Loss 0.003918808419257402, train accuracy 0.9634349030470915, val accuracy 0.
855072463768116
Iteration 746, epoch 14
Loss 0.003276020986959338, train accuracy 0.9750692520775623, val accuracy 0.
8695652173913043
Iteration 747, epoch 14
Loss 0.0011945834849029 78, train accuracy 0.9867036011080332, val accuracy 0.
8888888888888888
Iteration 748, epoch 14
Loss 0.00033729648566804826, train accuracy 0.9939058171745152, val accuracy
0.8985507246376812
Iteration 749, epoch 14
Loss 0.001950009842403233, train accuracy 0.9966759002770084, val accuracy 0.
9227053140096618
Iteration 750, epoch 14
Loss 0.0010878468165174127, train accuracy 0.997229916897507, val accuracy 0.
927536231884058
Iteration 751, epoch 14
Loss 0.0008509819163009524, train accuracy 0.9961218836565097, val accuracy
0.9371980676328503
Iteration 752, epoch 14
Loss 0.00027600605972111225, train accuracy 0.9950138504155125, val accuracy
0.9130434782608695
Iteration 753, epoch 14
Loss 0.00046524801291525364, train accuracy 0.9905817174515236, val accuracy
0.9130434782608695
Iteration 754, epoch 14
Loss 0.0011366978287696838, train accuracy 0.9878116343490305, val accuracy
0.8985507246376812
Iteration 755, epoch 14
Loss 0.0012378656538203359, train accuracy 0.9850415512465374, val accuracy
0.8888888888888888
Iteration 756, epoch 14
Loss 0.001012312131933868, train accuracy 0.9855955678670361, val accuracy 0.
8840579710144928
Iteration 757, epoch 14
Loss 0.0008166336920112371, train accuracy 0.9844875346260388, val accuracy
0.8840579710144928
Iteration 758, epoch 14
Loss 0.0002492086205165833, train accuracy 0.9839335180055402, val accuracy
0.8840579710144928
Iteration 759, epoch 14
Loss 0.003527505788952112, train accuracy 0.9867036011080332, val accuracy 0.
893719806763285
```

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Iteration 760, epoch 14
Loss 0.004559634253382683, train accuracy 0.9883656509695291, val accuracy 0.
8840579710144928
Iteration 761, epoch 14
Loss 0.0009249049471691251, train accuracy 0.9894736842105263, val accuracy
0.8840579710144928
Iteration 762, epoch 14
Loss 0.0004261657886672765, train accuracy 0.992797783933518, val accuracy 0.
8888888888888888
Iteration 763, epoch 14
Loss 0.0002412063768133521, train accuracy 0.9933518005540166, val accuracy
0.893719806763285
Iteration 764, epoch 14
Loss 0.0009650475694797933, train accuracy 0.9950138504155125, val accuracy
0.9082125603864735
Iteration 765, epoch 14
Loss 0.0005040239775553346, train accuracy 0.9944598337950139, val accuracy
0.9033816425120773
Iteration 766, epoch 14
Loss 0.00011483413254609331, train accuracy 0.9944598337950139, val accuracy
0.9082125603864735
Iteration 767, epoch 14
Loss 0.0005945430602878332, train accuracy 0.9944598337950139, val accuracy
0.9082125603864735
Iteration 768, epoch 14
Loss 0.0008617124403826892, train accuracy 0.9944598337950139, val accuracy
0.9033816425120773
Iteration 769, epoch 14
Loss 0.0005659285234287381, train accuracy 0.9955678670360111, val accuracy
0.9082125603864735
Iteration 770, epoch 14
Loss 0.000726393423974514, train accuracy 0.9955678670360111, val accuracy 0.
9178743961352657
Iteration 771, epoch 14
Loss 0.0003697503998409956 7, train accuracy 0.9955678670360111, val accuracy
0.9130434782608695
Iteration 772, epoch 14
Loss 0.00014260858006309718, train accuracy 0.9966759002770084, val accuracy
0.9178743961352657
Iteration 773, epoch 14
Loss 0.0003052834654226899, train accuracy 0.9966759002770084, val accuracy
0.9178743961352657
Iteration 774, epoch 14
Loss 0.0007954067550599575, train accuracy 0.997229916897507, val accuracy 0.
9130434782608695
Iteration 775, epoch 14
Loss 0.0015951704699546099, train accuracy 0.9966759002770084, val accuracy
0.9130434782608695
Iteration 776, epoch 14
Loss 0.0001401047338731587, train accuracy 0.9966759002770084, val accuracy
0.9178743961352657
Iteration 777, epoch 14
Loss 0.00020730073447339237, train accuracy 0.9944598337950139, val accuracy
0.9130434782608695
Iteration 778, epoch 14
Loss 0.0005226652137935162, train accuracy 0.9916897506925207, val accuracy
0.9082125603864735
```

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Iteration 779, epoch 14
Loss 0.002363804494962096, train accuracy 0.9950138504155125, val accuracy 0.
9178743961352657
Iteration 780, epoch 14
Loss 0.00044536858331412077, train accuracy 0.9966759002770084, val accuracy
0.9323671497584541
Iteration 781, epoch 14
Loss 0.000550322060007602, train accuracy 0.9983379501385041, val accuracy 0.
9371980676328503
Iteration 782, epoch 14
Loss 0.0002035822399193421, train accuracy 0.9988919667590028, val accuracy
0.9323671497584541
Iteration 783, epoch 14
Loss 0.0003894367255270481, train accuracy 0.9977839335180055, val accuracy
0.9323671497584541
Iteration 784, epoch 14
Loss 0.0001835258153732866, train accuracy 0.997229916897507, val accuracy 0.
9178743961352657
Iteration 785, epoch 14
Loss 0.00011802438530139625, train accuracy 0.997229916897507, val accuracy
0.9178743961352657
Iteration 786, epoch 14
Loss 0.00021503875905182213, train accuracy 0.9961218836565097, val accuracy
0.9178743961352657
Iteration 787, epoch 14
Loss 0.000520230969414115, train accuracy 0.9966759002770084, val accuracy 0.
9178743961352657
Iteration 788, epoch 14
Loss 0.0050232382491230965, train accuracy 0.9988919667590028, val accuracy
0.927536231884058
Iteration 789, epoch 14
Loss 0.0001518440549261868, train accuracy 0.9988919667590028, val accuracy
0.9371980676328503
Iteration 790, epoch 14
Loss 0.0009597679018042982, train accuracy 0.997229916897507, val accuracy 0.
9420289855072463
Iteration 791, epoch 14
Loss 0.0008640628075227141, train accuracy 0.9944598337950139, val accuracy
0.9323671497584541
Iteration 792, epoch 14
Loss 0.0004302964371163398, train accuracy 0.9883656509695291, val accuracy
0.9178743961352657
Iteration 793, epoch 14
Loss 0.003046507015824318, train accuracy 0.9872576177285318, val accuracy 0.
9178743961352657
Iteration 794, epoch 14
Loss 0.0008514249930158257, train accuracy 0.9883656509695291, val accuracy
0.9178743961352657
Iteration 795, epoch 14
Loss 0.0018583890050649643, train accuracy 0.9939058171745152, val accuracy
0.9178743961352657
Iteration 796, epoch 14
Loss 0.00011738915054593235, train accuracy 0.9955678670360111, val accuracy
0.9227053140096618
Iteration 797, epoch 14
Loss 0.0007224997792106408, train accuracy 0.9994459833795014, val accuracy
0.9371980676328503
```

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Iteration 798, epoch 15
Loss 6.377181853167713e-05, train accuracy 0.9988919667590028, val accuracy
0.927536231884058
Iteration 799, epoch 15
Loss 0.00046133139403536916, train accuracy 0.9983379501385041, val accuracy
0.927536231884058
Iteration 800, epoch 15
Loss 4.257772889104672e-05, train accuracy 0.9983379501385041, val accuracy
0.9178743961352657
Iteration 801, epoch 15
Loss 0.00016595465422142297, train accuracy 0.997229916897507, val accuracy
0.9082125603864735
Iteration 802, epoch 15
Loss 0.00011591544171096757, train accuracy 0.9950138504155125, val accuracy
0.9033816425120773
Iteration 803, epoch 15
Loss 8.053814235609025e-05, train accuracy 0.9944598337950139, val accuracy
0.8985507246376812
Iteration 804, epoch 15
Loss 0.0008768058032728732, train accuracy 0.9933518005540166, val accuracy
0.9033816425120773
Iteration 805, epoch 15
Loss 0.002176127163693309, train accuracy 0.9922437673130194, val accuracy 0.
9082125603864735
Iteration 806, epoch 15
Loss 0.00014859286602586508, train accuracy 0.992797783933518, val accuracy
0.8985507246376812
Iteration 807, epoch 15
Loss 0.0004912997246719897, train accuracy 0.9916897506925207, val accuracy
0.8985507246376812
Iteration 808, epoch 15
Loss 0.0008117142133414745, train accuracy 0.9939058171745152, val accuracy
0.8985507246376812
Iteration 809, epoch 15
Loss 0.00018147105583921075, train accuracy 0.9950138504155125, val accuracy
0.9130434782608695
Iteration 810, epoch 15
Loss 0.0005423445254564285, train accuracy 0.9961218836565097, val accuracy
0.9178743961352657
Iteration 811, epoch 15
Loss 0.000182630232302472, train accuracy 0.9966759002770084, val accuracy 0.
9178743961352657
Iteration 812, epoch 15
Loss 0.00016394822159782052, train accuracy 0.9966759002770084, val accuracy
0.9178743961352657
Iteration 813, epoch 15
Loss 0.00010717335680965334, train accuracy 0.9961218836565097, val accuracy
0.9227053140096618
Iteration 814, epoch 15
Loss 0.00040778203401714563, train accuracy 0.997229916897507, val accuracy
0.9227053140096618
Iteration 815, epoch 15
Loss 0.00012538711598608643, train accuracy 0.9977839335180055, val accuracy
0.9371980676328503
Iteration 816, epoch 15
Loss 0.0008777679759077728, train accuracy 0.997229916897507, val accuracy 0.
9420289855072463
```

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Iteration 817, epoch 15
Loss 0.0002963781589642167, train accuracy 0.997229916897507, val accuracy 0.
9468599033816425
Iteration 818, epoch 15
Loss 0.0002941911807283759, train accuracy 0.997229916897507, val accuracy 0.
9420289855072463
Iteration 819, epoch 15
Loss 0.0003629556449595839, train accuracy 0.9983379501385041, val accuracy
0.9371980676328503
Iteration 820, epoch 15
Loss 7.545697008026764e-05, train accuracy 0.9988919667590028, val accuracy
0.9323671497584541
Iteration 821, epoch 15
Loss 0.001083374721929431, train accuracy 0.9983379501385041, val accuracy 0.
9468599033816425
Iteration 822, epoch 15
Loss 0.0001102704482036642 7, train accuracy 0.9983379501385041, val accuracy
0.9468599033816425
Iteration 823, epoch 15
Loss 0.0003592232242226600 6, train accuracy 0.9983379501385041, val accuracy
0.9468599033816425
Iteration 824, epoch 15
Loss 0.0003899227594956755 6, train accuracy 0.9983379501385041, val accuracy
0.9468599033816425
Iteration 825, epoch 15
Loss 6.94918489898555e-05, train accuracy 0.9983379501385041, val accuracy 0.
9420289855072463
Iteration 826, epoch 15
Loss 0.0001027754769893363 1, train accuracy 0.9983379501385041, val accuracy
0.9371980676328503
Iteration 827, epoch 15
Loss 3.734212805284187e-05, train accuracy 0.9983379501385041, val accuracy
0.9371980676328503
Iteration 828, epoch 15
Loss 0.0007749105570837855, train accuracy 0.9988919667590028, val accuracy
0.9420289855072463
Iteration 829, epoch 15
Loss 7.099797221599147e-05, train accuracy 0.9994459833795014, val accuracy
0.9371980676328503
Iteration 830, epoch 15
Loss 6.423527520382777e-05, train accuracy 0.9994459833795014, val accuracy
0.9420289855072463
Iteration 831, epoch 15
Loss 6.757148366887122e-05, train accuracy 0.9994459833795014, val accuracy
0.9420289855072463
Iteration 832, epoch 15
Loss 8.113270450849086e-05, train accuracy 0.9994459833795014, val accuracy
0.9468599033816425
Iteration 833, epoch 15
Loss 6.826416938565671e-05, train accuracy 0.9994459833795014, val accuracy
0.9468599033816425
Iteration 834, epoch 15
Loss 9.40244717639871e-05, train accuracy 0.9994459833795014, val accuracy 0.
9371980676328503
Iteration 835, epoch 15
Loss 5.5207266996148974e-05, train accuracy 0.9994459833795014, val accuracy
0.9420289855072463
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Iteration 836, epoch 15
Loss 1.522839920653496e-05, train accuracy 0.9994459833795014, val accuracy
0.9420289855072463
Iteration 837, epoch 15
Loss 0.00016954839520622045, train accuracy 0.9994459833795014, val accuracy
0.9420289855072463
Iteration 838, epoch 15
Loss 0.00013201819092500955, train accuracy 0.9994459833795014, val accuracy
0.9468599033816425
Iteration 839, epoch 15
Loss 6.164568912936375e-05, train accuracy 0.9994459833795014, val accuracy
0.9468599033816425
Iteration 840, epoch 15
Loss 2.9556149456766434e-05, train accuracy 0.9994459833795014, val accuracy
0.9468599033816425
Iteration 841, epoch 15
Loss 0.00019312923541292548, train accuracy 0.9994459833795014, val accuracy
0.9468599033816425
Iteration 842, epoch 15
Loss 0.00040545323281548 92, train accuracy 0.9994459833795014, val accuracy
0.9420289855072463
Iteration 843, epoch 15
Loss 0.00016257370589300 99, train accuracy 0.9994459833795014, val accuracy
0.9420289855072463
Iteration 844, epoch 15
Loss 0.00025341636501252 65, train accuracy 0.9994459833795014, val accuracy
0.9468599033816425
Iteration 845, epoch 15
Loss 1.979449916689191e-05, train accuracy 0.9994459833795014, val accuracy
0.9468599033816425
Iteration 846, epoch 15
Loss 2.951715032395441e-05, train accuracy 0.9994459833795014, val accuracy
0.9420289855072463
Iteration 847, epoch 15
Loss 4.223964788252488e-05, train accuracy 0.9994459833795014, val accuracy
0.9420289855072463
Iteration 848, epoch 15
Loss 5.438811786007136e-05, train accuracy 0.9994459833795014, val accuracy
0.9420289855072463
Iteration 849, epoch 15
Loss 0.00016420408792328 09, train accuracy 0.9994459833795014, val accuracy
0.9420289855072463
Iteration 850, epoch 15
Loss 2.2946462195250206e-05, train accuracy 0.9994459833795014, val accuracy
0.9420289855072463
Iteration 851, epoch 15
Loss 0.00065575336338952 18, train accuracy 0.9994459833795014, val accuracy
0.9468599033816425
Iteration 852, epoch 15
Loss 5.658123366159 72e-05, train accuracy 0.9994459833795014, val accuracy
0.9516908212560387
Iteration 853, epoch 15
Loss 0.00010297481640009 21, train accuracy 0.9994459833795014, val accuracy
0.9468599033816425
Iteration 854, epoch 15
Loss 0.00371105997608258 16, train accuracy 0.9994459833795014, val accuracy
0.9420289855072463
```

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Iteration 855, epoch 16
Loss 5.011028770240955e-05, train accuracy 0.9994459833795014, val accuracy
0.9420289855072463
Iteration 856, epoch 16
Loss 1.7443528122385032e-05, train accuracy 0.9994459833795014, val accuracy
0.9371980676328503
Iteration 857, epoch 16
Loss 1.8348331650486216e-05, train accuracy 0.9994459833795014, val accuracy
0.9323671497584541
Iteration 858, epoch 16
Loss 5.4260734032141045e-05, train accuracy 0.9994459833795014, val accuracy
0.9323671497584541
Iteration 859, epoch 16
Loss 3.992782876593992e-05, train accuracy 0.9994459833795014, val accuracy
0.927536231884058
Iteration 860, epoch 16
Loss 6.097598452470265e-05, train accuracy 0.9994459833795014, val accuracy
0.9323671497584541
Iteration 861, epoch 16
Loss 1.1395287401683163e-05, train accuracy 0.9994459833795014, val accuracy
0.9323671497584541
Iteration 862, epoch 16
Loss 1.558246003696695e-05, train accuracy 0.9994459833795014, val accuracy
0.9323671497584541
Iteration 863, epoch 16
Loss 6.780910189263523e-05, train accuracy 0.9994459833795014, val accuracy
0.9323671497584541
Iteration 864, epoch 16
Loss 6.707011925755069e-05, train accuracy 0.9994459833795014, val accuracy
0.9323671497584541
Iteration 865, epoch 16
Loss 4.345419074525125e-05, train accuracy 0.9994459833795014, val accuracy
0.9323671497584541
Iteration 866, epoch 16
Loss 1.0717929399106652e-05, train accuracy 0.9994459833795014, val accuracy
0.9323671497584541
Iteration 867, epoch 16
Loss 5.5080687161535025e-05, train accuracy 0.9994459833795014, val accuracy
0.9323671497584541
Iteration 868, epoch 16
Loss 7.112194452929543e-06, train accuracy 0.9994459833795014, val accuracy
0.9323671497584541
Iteration 869, epoch 16
Loss 8.890839126252104e-06, train accuracy 0.9994459833795014, val accuracy
0.9323671497584541
Iteration 870, epoch 16
Loss 8.036340659600683e-06, train accuracy 0.9994459833795014, val accuracy
0.927536231884058
Iteration 871, epoch 16
Loss 0.002978734904900193, train accuracy 0.9994459833795014, val accuracy 0.
927536231884058
Iteration 872, epoch 16
Loss 1.4289827049651649e-05, train accuracy 0.9994459833795014, val accuracy
0.9178743961352657
Iteration 873, epoch 16
Loss 5.93131007917691e-05, train accuracy 0.9994459833795014, val accuracy 0.
9178743961352657
```

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Iteration 874, epoch 16
Loss 4.435540540725924e-05, train accuracy 0.9994459833795014, val accuracy
0.9033816425120773
Iteration 875, epoch 16
Loss 0.00016013396088965237, train accuracy 0.9994459833795014, val accuracy
0.9033816425120773
Iteration 876, epoch 16
Loss 3.4707591112237424e-05, train accuracy 0.9994459833795014, val accuracy
0.9033816425120773
Iteration 877, epoch 16
Loss 0.00031912169652059674, train accuracy 0.9994459833795014, val accuracy
0.9033816425120773
Iteration 878, epoch 16
Loss 4.0125029045157135e-05, train accuracy 0.9994459833795014, val accuracy
0.9033816425120773
Iteration 879, epoch 16
Loss 0.005222099833190441, train accuracy 0.9994459833795014, val accuracy 0.
9082125603864735
Iteration 880, epoch 16
Loss 1.936852277140133e-05, train accuracy 0.9994459833795014, val accuracy
0.9227053140096618
Iteration 881, epoch 16
Loss 1.8578884919406846e-05, train accuracy 0.9994459833795014, val accuracy
0.9323671497584541
Iteration 882, epoch 16
Loss 0.00012231945584062487, train accuracy 0.9994459833795014, val accuracy
0.9371980676328503
Iteration 883, epoch 16
Loss 3.0500852517434396e-05, train accuracy 0.9994459833795014, val accuracy
0.9371980676328503
Iteration 884, epoch 16
Loss 3.660577203845605e-05, train accuracy 0.9994459833795014, val accuracy
0.9323671497584541
Iteration 885, epoch 16
Loss 3.193724114680663e-05, train accuracy 0.9994459833795014, val accuracy
0.9323671497584541
Iteration 886, epoch 16
Loss 3.672997627290897e-05, train accuracy 0.9994459833795014, val accuracy
0.9371980676328503
Iteration 887, epoch 16
Loss 1.4972336430219002e-05, train accuracy 0.9994459833795014, val accuracy
0.9420289855072463
Iteration 888, epoch 16
Loss 2.2423320842790417e-05, train accuracy 0.9994459833795014, val accuracy
0.9420289855072463
Iteration 889, epoch 16
Loss 0.00048785150283947587, train accuracy 0.9994459833795014, val accuracy
0.9420289855072463
Iteration 890, epoch 16
Loss 3.348198515595868e-05, train accuracy 0.9994459833795014, val accuracy
0.9420289855072463
Iteration 891, epoch 16
Loss 1.683686423348263e-05, train accuracy 0.9994459833795014, val accuracy
0.9420289855072463
Iteration 892, epoch 16
Loss 0.00012992127449251711, train accuracy 0.9994459833795014, val accuracy
0.9420289855072463
```

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Iteration 893, epoch 16
Loss 0.00011374198220437393, train accuracy 0.9994459833795014, val accuracy
0.9420289855072463
Iteration 894, epoch 16
Loss 5.728447649744339e-05, train accuracy 0.9994459833795014, val accuracy
0.9420289855072463
Iteration 895, epoch 16
Loss 1.6403435438405722e-05, train accuracy 0.9994459833795014, val accuracy
0.9420289855072463
Iteration 896, epoch 16
Loss 3.141388879157603e-05, train accuracy 0.9994459833795014, val accuracy
0.9420289855072463
Iteration 897, epoch 16
Loss 1.7437405404052697e-05, train accuracy 0.9994459833795014, val accuracy
0.9420289855072463
Iteration 898, epoch 16
Loss 2.43804206547793e-05, train accuracy 0.9994459833795014, val accuracy 0.
9468599033816425
Iteration 899, epoch 16
Loss 0.00010253527580061927, train accuracy 0.9994459833795014, val accuracy
0.9468599033816425
Iteration 900, epoch 16
Loss 2.1854024453205056e-05, train accuracy 0.9994459833795014, val accuracy
0.9468599033816425
Iteration 901, epoch 16
Loss 0.0001383355411235243, train accuracy 0.9994459833795014, val accuracy
0.9468599033816425
Iteration 902, epoch 16
Loss 6.429228960769251e-06, train accuracy 0.9994459833795014, val accuracy
0.9468599033816425
Iteration 903, epoch 16
Loss 0.00019721737771760672, train accuracy 0.9994459833795014, val accuracy
0.9468599033816425
Iteration 904, epoch 16
Loss 7.108163845259696e-05, train accuracy 0.9994459833795014, val accuracy
0.9323671497584541
Iteration 905, epoch 16
Loss 5.8366465964354575e-05, train accuracy 0.9994459833795014, val accuracy
0.927536231884058
Iteration 906, epoch 16
Loss 6.425985338864848e-05, train accuracy 0.9994459833795014, val accuracy
0.927536231884058
Iteration 907, epoch 16
Loss 4.8804493417264894e-05, train accuracy 0.9994459833795014, val accuracy
0.927536231884058
Iteration 908, epoch 16
Loss 1.0979217222484294e-05, train accuracy 0.9994459833795014, val accuracy
0.9323671497584541
Iteration 909, epoch 16
Loss 6.640604260610417e-05, train accuracy 0.9994459833795014, val accuracy
0.9323671497584541
Iteration 910, epoch 16
Loss 3.378493056516163e-05, train accuracy 0.9994459833795014, val accuracy
0.9323671497584541
Iteration 911, epoch 16
Loss 0.0001540046471815843, train accuracy 0.9994459833795014, val accuracy
0.9323671497584541
```

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Iteration 912, epoch 17
Loss 1.9110040739178658e-05, train accuracy 0.9994459833795014, val accuracy
0.927536231884058
Iteration 913, epoch 17
Loss 6.567996024386957e-06, train accuracy 0.9994459833795014, val accuracy
0.927536231884058
Iteration 914, epoch 17
Loss 0.002458904404193163, train accuracy 0.9994459833795014, val accuracy 0.
927536231884058
Iteration 915, epoch 17
Loss 1.9881437765434384e-05, train accuracy 0.9994459833795014, val accuracy
0.9227053140096618
Iteration 916, epoch 17
Loss 3.507535075186752e-05, train accuracy 0.9994459833795014, val accuracy
0.9227053140096618
Iteration 917, epoch 17
Loss 2.9085265850881115e-05, train accuracy 0.9994459833795014, val accuracy
0.9227053140096618
Iteration 918, epoch 17
Loss 3.930875755031593e-05, train accuracy 0.9994459833795014, val accuracy
0.927536231884058
Iteration 919, epoch 17
Loss 0.00011802147491835058, train accuracy 0.9994459833795014, val accuracy
0.9227053140096618
Iteration 920, epoch 17
Loss 6.456692062783986e-05, train accuracy 0.9994459833795014, val accuracy
0.927536231884058
Iteration 921, epoch 17
Loss 3.783468491747044e-05, train accuracy 0.9994459833795014, val accuracy
0.9178743961352657
Iteration 922, epoch 17
Loss 0.0002020002866629511, train accuracy 0.9994459833795014, val accuracy
0.9178743961352657
Iteration 923, epoch 17
Loss 0.000140066011226736, train accuracy 0.9994459833795014, val accuracy 0.
9227053140096618
Iteration 924, epoch 17
Loss 0.00011175899271620438, train accuracy 0.9994459833795014, val accuracy
0.9227053140096618
Iteration 925, epoch 17
Loss 7.659880793653429e-06, train accuracy 0.9994459833795014, val accuracy
0.9227053140096618
Iteration 926, epoch 17
Loss 7.325989281525835e-05, train accuracy 0.9994459833795014, val accuracy
0.927536231884058
Iteration 927, epoch 17
Loss 1.0359455700381659e-05, train accuracy 0.9994459833795014, val accuracy
0.927536231884058
Iteration 928, epoch 17
Loss 6.947127258172259e-05, train accuracy 0.9994459833795014, val accuracy
0.927536231884058
Iteration 929, epoch 17
Loss 1.4280062714533415e-05, train accuracy 0.9994459833795014, val accuracy
0.927536231884058
Iteration 930, epoch 17
Loss 4.1152943595079705e-05, train accuracy 0.9994459833795014, val accuracy
0.927536231884058
```

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Iteration 931, epoch 17
Loss 6.613742880290374e-05, train accuracy 0.9994459833795014, val accuracy
0.927536231884058
Iteration 932, epoch 17
Loss 7.696040847804397e-05, train accuracy 0.9994459833795014, val accuracy
0.927536231884058
Iteration 933, epoch 17
Loss 5.860475357621908e-05, train accuracy 0.9994459833795014, val accuracy
0.927536231884058
Iteration 934, epoch 17
Loss 2.6098461603396572e-05, train accuracy 0.9994459833795014, val accuracy
0.927536231884058
Iteration 935, epoch 17
Loss 4.496787369134836e-05, train accuracy 0.9994459833795014, val accuracy
0.927536231884058
Iteration 936, epoch 17
Loss 1.5255322068696842e-05, train accuracy 0.9994459833795014, val accuracy
0.927536231884058
Iteration 937, epoch 17
Loss 0.003581585129722953, train accuracy 0.9994459833795014, val accuracy 0.
927536231884058
Iteration 938, epoch 17
Loss 2.8526861569844186e-05, train accuracy 0.9994459833795014, val accuracy
0.9323671497584541
Iteration 939, epoch 17
Loss 5.749943375121802e-05, train accuracy 0.9994459833795014, val accuracy
0.9420289855072463
Iteration 940, epoch 17
Loss 2.272354504384566e-05, train accuracy 0.9994459833795014, val accuracy
0.9371980676328503
Iteration 941, epoch 17
Loss 6.660132203251123e-05, train accuracy 0.9994459833795014, val accuracy
0.9371980676328503
Iteration 942, epoch 17
Loss 2.1672211005352437e-05, train accuracy 0.9994459833795014, val accuracy
0.9371980676328503
Iteration 943, epoch 17
Loss 2.994151509483345e-05, train accuracy 0.9994459833795014, val accuracy
0.9371980676328503
Iteration 944, epoch 17
Loss 8.867231372278184e-06, train accuracy 0.9994459833795014, val accuracy
0.9371980676328503
Iteration 945, epoch 17
Loss 0.00017477551591582596, train accuracy 0.9994459833795014, val accuracy
0.9323671497584541
Iteration 946, epoch 17
Loss 6.825368473073468e-06, train accuracy 0.9994459833795014, val accuracy
0.9323671497584541
Iteration 947, epoch 17
Loss 1.8534037735662423e-06, train accuracy 0.9994459833795014, val accuracy
0.9323671497584541
Iteration 948, epoch 17
Loss 3.1052106351125985e-05, train accuracy 0.9994459833795014, val accuracy
0.9371980676328503
Iteration 949, epoch 17
Loss 1.1274074495304376e-05, train accuracy 0.9994459833795014, val accuracy
0.9371980676328503
```

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Iteration 950, epoch 17
Loss 3.031150481547229e-05, train accuracy 0.9994459833795014, val accuracy
0.9371980676328503
Iteration 951, epoch 17
Loss 4.2509509512456134e-05, train accuracy 0.9994459833795014, val accuracy
0.9371980676328503
Iteration 952, epoch 17
Loss 1.5956382412696257e-05, train accuracy 0.9994459833795014, val accuracy
0.9371980676328503
Iteration 953, epoch 17
Loss 2.417765063000843e-05, train accuracy 0.9994459833795014, val accuracy
0.9371980676328503
Iteration 954, epoch 17
Loss 1.2728821275231894e-05, train accuracy 0.9994459833795014, val accuracy
0.9371980676328503
Iteration 955, epoch 17
Loss 3.596892565838061e-05, train accuracy 0.9994459833795014, val accuracy
0.9371980676328503
Iteration 956, epoch 17
Loss 1.4749761248822324e-05, train accuracy 0.9994459833795014, val accuracy
0.9371980676328503
Iteration 957, epoch 17
Loss 3.733225821633823e-05, train accuracy 0.9994459833795014, val accuracy
0.9371980676328503
Iteration 958, epoch 17
Loss 4.642600106308237e-05, train accuracy 0.9994459833795014, val accuracy
0.9371980676328503
Iteration 959, epoch 17
Loss 8.866174539434724e-06, train accuracy 0.9994459833795014, val accuracy
0.9371980676328503
Iteration 960, epoch 17
Loss 7.005824591033161e-05, train accuracy 0.9994459833795014, val accuracy
0.9323671497584541
Iteration 961, epoch 17
Loss 4.1063631215365604e-05, train accuracy 0.9994459833795014, val accuracy
0.9323671497584541
Iteration 962, epoch 17
Loss 2.6324876671424136e-05, train accuracy 0.9994459833795014, val accuracy
0.9323671497584541
Iteration 963, epoch 17
Loss 2.6140533009311184e-05, train accuracy 0.9994459833795014, val accuracy
0.9323671497584541
Iteration 964, epoch 17
Loss 1.748240174492821e-05, train accuracy 0.9994459833795014, val accuracy
0.9323671497584541
Iteration 965, epoch 17
Loss 0.00011880446982104331, train accuracy 0.9994459833795014, val accuracy
0.9323671497584541
Iteration 966, epoch 17
Loss 1.6395470083807595e-05, train accuracy 0.9994459833795014, val accuracy
0.9323671497584541
Iteration 967, epoch 17
Loss 5.57547946300474e-06, train accuracy 0.9994459833795014, val accuracy 0.
9323671497584541
Iteration 968, epoch 17
Loss 7.171756050621088e-05, train accuracy 0.9994459833795014, val accuracy
0.9371980676328503
```

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Iteration 969, epoch 18
Loss 5.167424205865245e-06, train accuracy 0.9994459833795014, val accuracy
0.9371980676328503
Iteration 970, epoch 18
Loss 2.7832147679873742e-05, train accuracy 0.9994459833795014, val accuracy
0.9371980676328503
Iteration 971, epoch 18
Loss 3.6121684388490394e-05, train accuracy 0.9994459833795014, val accuracy
0.9371980676328503
Iteration 972, epoch 18
Loss 8.260650247393642e-06, train accuracy 0.9994459833795014, val accuracy
0.9371980676328503
Iteration 973, epoch 18
Loss 2.111537696691812e-06, train accuracy 0.9994459833795014, val accuracy
0.9371980676328503
Iteration 974, epoch 18
Loss 9.923934703692794e-05, train accuracy 0.9994459833795014, val accuracy
0.9371980676328503
Iteration 975, epoch 18
Loss 1.2204265658510849e-05, train accuracy 0.9994459833795014, val accuracy
0.9420289855072463
Iteration 976, epoch 18
Loss 1.533600516268052e-05, train accuracy 0.9994459833795014, val accuracy
0.9371980676328503
Iteration 977, epoch 18
Loss 1.4681189895782154e-05, train accuracy 0.9994459833795014, val accuracy
0.9420289855072463
Iteration 978, epoch 18
Loss 1.599868483026512e-05, train accuracy 0.9994459833795014, val accuracy
0.9420289855072463
Iteration 979, epoch 18
Loss 3.95424067392014e-05, train accuracy 0.9994459833795014, val accuracy 0.
9371980676328503
Iteration 980, epoch 18
Loss 2.3409811547026038e-05, train accuracy 0.9994459833795014, val accuracy
0.9371980676328503
Iteration 981, epoch 18
Loss 1.603337295819074e-05, train accuracy 0.9994459833795014, val accuracy
0.9371980676328503
Iteration 982, epoch 18
Loss 0.0033089302014559507, train accuracy 0.9994459833795014, val accuracy
0.9323671497584541
Iteration 983, epoch 18
Loss 1.8142467524739914e-05, train accuracy 0.9994459833795014, val accuracy
0.9323671497584541
Iteration 984, epoch 18
Loss 5.209769369685091e-06, train accuracy 0.9994459833795014, val accuracy
0.9323671497584541
Iteration 985, epoch 18
Loss 1.3536259757529479e-05, train accuracy 0.9994459833795014, val accuracy
0.9323671497584541
Iteration 986, epoch 18
Loss 4.097466080565937e-05, train accuracy 0.9994459833795014, val accuracy
0.9323671497584541
Iteration 987, epoch 18
Loss 3.782671774388291e-05, train accuracy 0.9994459833795014, val accuracy
0.927536231884058
```

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Iteration 988, epoch 18
Loss 5.994750608806498e-06, train accuracy 0.9994459833795014, val accuracy
0.927536231884058
Iteration 989, epoch 18
Loss 2.375679468968883e-05, train accuracy 0.9994459833795014, val accuracy
0.9178743961352657
Iteration 990, epoch 18
Loss 9.100741590373218e-05, train accuracy 0.9994459833795014, val accuracy
0.9178743961352657
Iteration 991, epoch 18
Loss 1.716848237265367e-05, train accuracy 0.9994459833795014, val accuracy
0.9178743961352657
Iteration 992, epoch 18
Loss 2.5381319574080408e-05, train accuracy 0.9994459833795014, val accuracy
0.9178743961352657
Iteration 993, epoch 18
Loss 1.243421957042301e-05, train accuracy 0.9994459833795014, val accuracy
0.9178743961352657
Iteration 994, epoch 18
Loss 2.394994953647256e-05, train accuracy 0.9994459833795014, val accuracy
0.9178743961352657
Iteration 995, epoch 18
Loss 0.0004494229215197265, train accuracy 0.9994459833795014, val accuracy
0.9178743961352657
Iteration 996, epoch 18
Loss 4.893482764600776e-05, train accuracy 0.9994459833795014, val accuracy
0.9178743961352657
Iteration 997, epoch 18
Loss 5.730695920647122e-05, train accuracy 0.9994459833795014, val accuracy
0.9227053140096618
Iteration 998, epoch 18
Loss 3.580950215109624e-05, train accuracy 0.9994459833795014, val accuracy
0.9227053140096618
Iteration 999, epoch 18
Loss 2.726570346567314e-05, train accuracy 0.9994459833795014, val accuracy
0.927536231884058
Iteration 1000, epoch 18
Loss 1.0428641871840227e-05, train accuracy 0.9994459833795014, val accuracy
0.927536231884058
Iteration 1001, epoch 18
Loss 7.241232378873974e-05, train accuracy 0.9994459833795014, val accuracy
0.927536231884058
Iteration 1002, epoch 18
Loss 5.052093183621764e-05, train accuracy 0.9994459833795014, val accuracy
0.927536231884058
Iteration 1003, epoch 18
Loss 1.829796383390203e-05, train accuracy 0.9994459833795014, val accuracy
0.927536231884058
Iteration 1004, epoch 18
Loss 4.080577127751894e-05, train accuracy 0.9994459833795014, val accuracy
0.927536231884058
Iteration 1005, epoch 18
Loss 1.1515259757288732e-05, train accuracy 0.9994459833795014, val accuracy
0.9227053140096618
Iteration 1006, epoch 18
Loss 2.2128990167402662e-05, train accuracy 0.9994459833795014, val accuracy
0.9227053140096618
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Iteration 1007, epoch 18
Loss 2.4429024051642045e-05, train accuracy 0.9994459833795014, val accuracy
0.9227053140096618
Iteration 1008, epoch 18
Loss 6.77439384162426e-05, train accuracy 0.9994459833795014, val accuracy 0.
9227053140096618
Iteration 1009, epoch 18
Loss 6.431881956814323e-06, train accuracy 0.9994459833795014, val accuracy
0.9227053140096618
Iteration 1010, epoch 18
Loss 3.765593419302604e-06, train accuracy 0.9994459833795014, val accuracy
0.9227053140096618
Iteration 1011, epoch 18
Loss 2.874785968742799e-05, train accuracy 0.9994459833795014, val accuracy
0.9178743961352657
Iteration 1012, epoch 18
Loss 1.3592323739430867e-05, train accuracy 0.9994459833795014, val accuracy
0.9227053140096618
Iteration 1013, epoch 18
Loss 4.361978062661365e-05, train accuracy 0.9994459833795014, val accuracy
0.9227053140096618
Iteration 1014, epoch 18
Loss 2.5881396140903234e-05, train accuracy 0.9994459833795014, val accuracy
0.9227053140096618
Iteration 1015, epoch 18
Loss 1.1920796168851666e-05, train accuracy 0.9994459833795014, val accuracy
0.9227053140096618
Iteration 1016, epoch 18
Loss 1.680076638876926e-05, train accuracy 0.9994459833795014, val accuracy
0.9227053140096618
Iteration 1017, epoch 18
Loss 1.1747913958970457e-05, train accuracy 0.9994459833795014, val accuracy
0.9227053140096618
Iteration 1018, epoch 18
Loss 0.0018946765922009945, train accuracy 0.9994459833795014, val accuracy
0.9323671497584541
Iteration 1019, epoch 18
Loss 8.294618055515457e-06, train accuracy 0.9994459833795014, val accuracy
0.9323671497584541
Iteration 1020, epoch 18
Loss 3.1472471164306626e-05, train accuracy 0.9994459833795014, val accuracy
0.9323671497584541
Iteration 1021, epoch 18
Loss 2.9627439289470203e-05, train accuracy 0.9994459833795014, val accuracy
0.9323671497584541
Iteration 1022, epoch 18
Loss 8.625606824352872e-06, train accuracy 0.9994459833795014, val accuracy
0.9371980676328503
Iteration 1023, epoch 18
Loss 2.4100165319396183e-05, train accuracy 0.9994459833795014, val accuracy
0.9371980676328503
Iteration 1024, epoch 18
Loss 3.390058554941788e-05, train accuracy 0.9994459833795014, val accuracy
0.9371980676328503
Iteration 1025, epoch 18
Loss 0.00020266985162519492, train accuracy 0.9994459833795014, val accuracy
0.9371980676328503
```

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Iteration 1026, epoch 19
Loss 3.141119668725878e-05, train accuracy 0.9994459833795014, val accuracy
0.9371980676328503
Iteration 1027, epoch 19
Loss 1.777017132553737 6e-05, train accuracy 0.9994459833795014, val accuracy
0.9371980676328503
Iteration 1028, epoch 19
Loss 7.791424650349654e-06, train accuracy 0.9994459833795014, val accuracy
0.9371980676328503
Iteration 1029, epoch 19
Loss 6.628221308346838e-05, train accuracy 0.9994459833795014, val accuracy
0.9371980676328503
Iteration 1030, epoch 19
Loss 2.990157008753158e-05, train accuracy 0.9994459833795014, val accuracy
0.9371980676328503
Iteration 1031, epoch 19
Loss 3.0188575692591257e-05, train accuracy 0.9994459833795014, val accuracy
0.9371980676328503
Iteration 1032, epoch 19
Loss 6.57205509924097e-06, train accuracy 0.9994459833795014, val accuracy 0.
9371980676328503
Iteration 1033, epoch 19
Loss 3.081870818277821e-05, train accuracy 0.9994459833795014, val accuracy
0.9371980676328503
Iteration 1034, epoch 19
Loss 4.0747439925326034e-05, train accuracy 0.9994459833795014, val accuracy
0.9371980676328503
Iteration 1035, epoch 19
Loss 2.3537373635917902e-05, train accuracy 0.9994459833795014, val accuracy
0.9371980676328503
Iteration 1036, epoch 19
Loss 0.0003844398306682706, train accuracy 0.9994459833795014, val accuracy
0.9323671497584541
Iteration 1037, epoch 19
Loss 5.874318958376534e-06, train accuracy 0.9994459833795014, val accuracy
0.9323671497584541
Iteration 1038, epoch 19
Loss 1.78457466972759e-05, train accuracy 0.9994459833795014, val accuracy 0.
9323671497584541
Iteration 1039, epoch 19
Loss 2.064937689283397e-05, train accuracy 0.9994459833795014, val accuracy
0.9323671497584541
Iteration 1040, epoch 19
Loss 1.1095542504335754e-05, train accuracy 0.9994459833795014, val accuracy
0.9227053140096618
Iteration 1041, epoch 19
Loss 1.6086707546492107e-05, train accuracy 0.9994459833795014, val accuracy
0.9227053140096618
Iteration 1042, epoch 19
Loss 1.5923307728371583e-05, train accuracy 0.9994459833795014, val accuracy
0.9178743961352657
Iteration 1043, epoch 19
Loss 8.209640327550005e-06, train accuracy 0.9994459833795014, val accuracy
0.9178743961352657
Iteration 1044, epoch 19
Loss 5.4960996749287006e-06, train accuracy 0.9994459833795014, val accuracy
0.927536231884058
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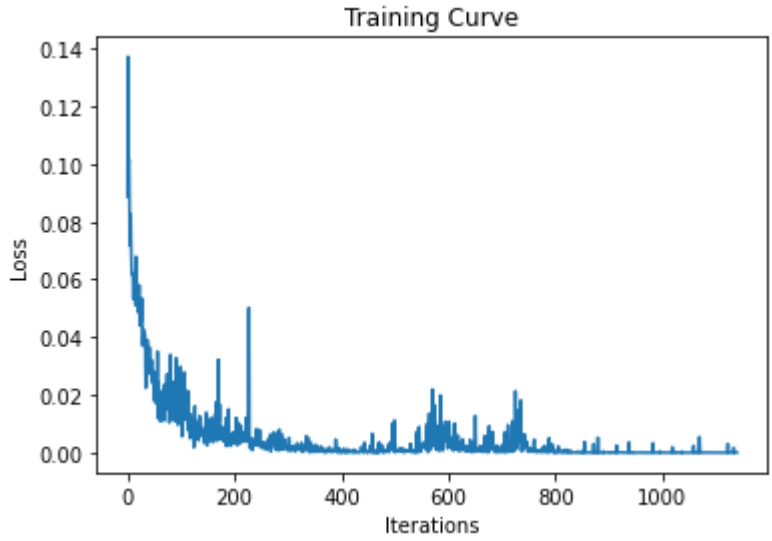
Iteration 1045, epoch 19
Loss 4.448155323188985e-06, train accuracy 0.9994459833795014, val accuracy
0.927536231884058
Iteration 1046, epoch 19
Loss 9.451554433326237e-06, train accuracy 0.9994459833795014, val accuracy
0.927536231884058
Iteration 1047, epoch 19
Loss 1.2931468518218026e-05, train accuracy 0.9994459833795014, val accuracy
0.927536231884058
Iteration 1048, epoch 19
Loss 2.0028621293022297e-05, train accuracy 0.9994459833795014, val accuracy
0.927536231884058
Iteration 1049, epoch 19
Loss 2.055316508631222e-05, train accuracy 0.9994459833795014, val accuracy
0.927536231884058
Iteration 1050, epoch 19
Loss 5.147761839907616e-06, train accuracy 0.9994459833795014, val accuracy
0.927536231884058
Iteration 1051, epoch 19
Loss 1.1202455425518565e-05, train accuracy 0.9994459833795014, val accuracy
0.927536231884058
Iteration 1052, epoch 19
Loss 2.60637971223332e-05, train accuracy 0.9994459833795014, val accuracy 0.
927536231884058
Iteration 1053, epoch 19
Loss 1.2585430340550374e-05, train accuracy 0.9994459833795014, val accuracy
0.927536231884058
Iteration 1054, epoch 19
Loss 3.0181423426256515e-05, train accuracy 0.9994459833795014, val accuracy
0.927536231884058
Iteration 1055, epoch 19
Loss 2.042665309053553e-06, train accuracy 0.9994459833795014, val accuracy
0.927536231884058
Iteration 1056, epoch 19
Loss 1.1591472684813198e-05, train accuracy 0.9994459833795014, val accuracy
0.927536231884058
Iteration 1057, epoch 19
Loss 2.392508031334728e-05, train accuracy 0.9994459833795014, val accuracy
0.927536231884058
Iteration 1058, epoch 19
Loss 0.002380736405029893, train accuracy 0.9994459833795014, val accuracy 0.
927536231884058
Iteration 1059, epoch 19
Loss 3.2526306313229725e-05, train accuracy 0.9994459833795014, val accuracy
0.9227053140096618
Iteration 1060, epoch 19
Loss 2.743560071394313e-05, train accuracy 0.9994459833795014, val accuracy
0.9178743961352657
Iteration 1061, epoch 19
Loss 8.095437806332484e-05, train accuracy 0.9994459833795014, val accuracy
0.9178743961352657
Iteration 1062, epoch 19
Loss 6.601195491384715e-05, train accuracy 0.9994459833795014, val accuracy
0.9082125603864735
Iteration 1063, epoch 19
Loss 4.452783468877897e-05, train accuracy 0.9988919667590028, val accuracy
0.9082125603864735
```

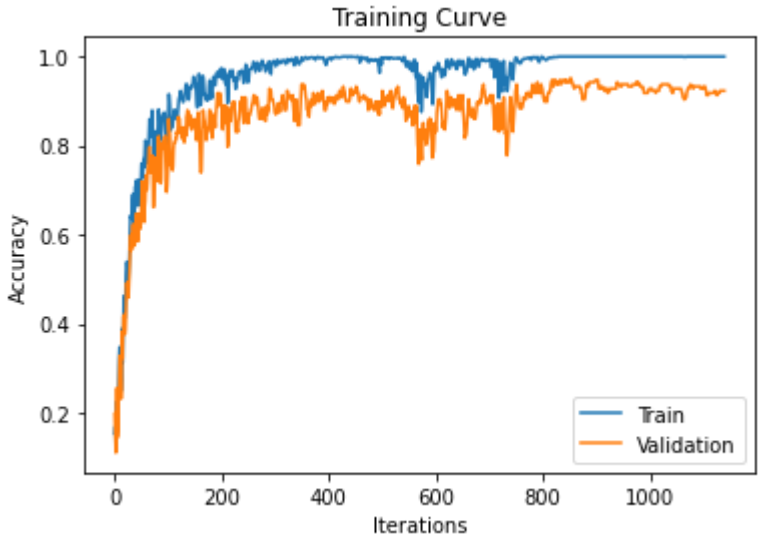
```
Iteration 1064, epoch 19
Loss 1.6586589481448755e-05, train accuracy 0.9988919667590028, val accuracy
0.9033816425120773
Iteration 1065, epoch 19
Loss 0.0002963671286124736, train accuracy 0.9988919667590028, val accuracy
0.9033816425120773
Iteration 1066, epoch 19
Loss 3.621598443714902e-05, train accuracy 0.9988919667590028, val accuracy
0.9082125603864735
Iteration 1067, epoch 19
Loss 3.959565219702199e-05, train accuracy 0.9988919667590028, val accuracy
0.9082125603864735
Iteration 1068, epoch 19
Loss 1.892881846288219e-05, train accuracy 0.9988919667590028, val accuracy
0.9082125603864735
Iteration 1069, epoch 19
Loss 0.005432341247797012, train accuracy 0.9994459833795014, val accuracy 0.
9178743961352657
Iteration 1070, epoch 19
Loss 0.00013308034976944327, train accuracy 0.9994459833795014, val accuracy
0.9227053140096618
Iteration 1071, epoch 19
Loss 5.868785228813067e-05, train accuracy 0.9994459833795014, val accuracy
0.927536231884058
Iteration 1072, epoch 19
Loss 1.0697496691136621e-05, train accuracy 0.9994459833795014, val accuracy
0.927536231884058
Iteration 1073, epoch 19
Loss 1.788003464753274e-05, train accuracy 0.9994459833795014, val accuracy
0.927536231884058
Iteration 1074, epoch 19
Loss 2.2792708477936685e-05, train accuracy 0.9994459833795014, val accuracy
0.9323671497584541
Iteration 1075, epoch 19
Loss 1.118710952141555e-05, train accuracy 0.9994459833795014, val accuracy
0.9323671497584541
Iteration 1076, epoch 19
Loss 1.047142177412752e-05, train accuracy 0.9994459833795014, val accuracy
0.9371980676328503
Iteration 1077, epoch 19
Loss 1.710109609120991e-05, train accuracy 0.9994459833795014, val accuracy
0.9323671497584541
Iteration 1078, epoch 19
Loss 1.3142265743226744e-05, train accuracy 0.9994459833795014, val accuracy
0.9323671497584541
Iteration 1079, epoch 19
Loss 0.0001125388007494621, train accuracy 0.9994459833795014, val accuracy
0.9323671497584541
Iteration 1080, epoch 19
Loss 1.889427767309826e-05, train accuracy 0.9994459833795014, val accuracy
0.9323671497584541
Iteration 1081, epoch 19
Loss 1.4086180044614593e-06, train accuracy 0.9994459833795014, val accuracy
0.927536231884058
Iteration 1082, epoch 19
Loss 2.5556904102603978e-05, train accuracy 0.9994459833795014, val accuracy
0.9323671497584541
```

```
Iteration 1083, epoch 20
Loss 1.7308899259660393e-05, train accuracy 0.9994459833795014, val accuracy
0.9323671497584541
Iteration 1084, epoch 20
Loss 4.987181819160469e-05, train accuracy 0.9994459833795014, val accuracy
0.9323671497584541
Iteration 1085, epoch 20
Loss 2.647204564709682e-05, train accuracy 0.9994459833795014, val accuracy
0.9323671497584541
Iteration 1086, epoch 20
Loss 2.4421804482699372e-05, train accuracy 0.9994459833795014, val accuracy
0.9323671497584541
Iteration 1087, epoch 20
Loss 1.5908397472230718e-05, train accuracy 0.9994459833795014, val accuracy
0.9323671497584541
Iteration 1088, epoch 20
Loss 4.5426961150951684e-05, train accuracy 0.9994459833795014, val accuracy
0.9323671497584541
Iteration 1089, epoch 20
Loss 2.625779961817898e-05, train accuracy 0.9994459833795014, val accuracy
0.9323671497584541
Iteration 1090, epoch 20
Loss 4.054013970744563e-06, train accuracy 0.9994459833795014, val accuracy
0.9323671497584541
Iteration 1091, epoch 20
Loss 4.80226990475785e-05, train accuracy 0.9994459833795014, val accuracy 0.
9323671497584541
Iteration 1092, epoch 20
Loss 9.815495104703587e-06, train accuracy 0.9994459833795014, val accuracy
0.9323671497584541
Iteration 1093, epoch 20
Loss 3.0275346944108605e-05, train accuracy 0.9994459833795014, val accuracy
0.9323671497584541
Iteration 1094, epoch 20
Loss 6.995893636485562e-05, train accuracy 0.9994459833795014, val accuracy
0.9323671497584541
Iteration 1095, epoch 20
Loss 5.4047843150328845e-05, train accuracy 0.9994459833795014, val accuracy
0.927536231884058
Iteration 1096, epoch 20
Loss 4.2326337279519066e-05, train accuracy 0.9994459833795014, val accuracy
0.927536231884058
Iteration 1097, epoch 20
Loss 7.005967290751869e-06, train accuracy 0.9994459833795014, val accuracy
0.927536231884058
Iteration 1098, epoch 20
Loss 5.367664198274724e-05, train accuracy 0.9994459833795014, val accuracy
0.927536231884058
Iteration 1099, epoch 20
Loss 1.1114235348941293e-05, train accuracy 0.9994459833795014, val accuracy
0.927536231884058
Iteration 1100, epoch 20
Loss 9.081166354008019e-06, train accuracy 0.9994459833795014, val accuracy
0.9323671497584541
Iteration 1101, epoch 20
Loss 1.8109376469510607e-05, train accuracy 0.9994459833795014, val accuracy
0.9323671497584541
```

```
Iteration 1102, epoch 20
Loss 5.219083686824888e-05, train accuracy 0.9994459833795014, val accuracy
0.9323671497584541
Iteration 1103, epoch 20
Loss 7.087260200933088e-06, train accuracy 0.9994459833795014, val accuracy
0.9323671497584541
Iteration 1104, epoch 20
Loss 3.578886435207096e-06, train accuracy 0.9994459833795014, val accuracy
0.927536231884058
Iteration 1105, epoch 20
Loss 1.9544224414858036e-05, train accuracy 0.9994459833795014, val accuracy
0.9227053140096618
Iteration 1106, epoch 20
Loss 1.3562976164394058e-05, train accuracy 0.9994459833795014, val accuracy
0.9130434782608695
Iteration 1107, epoch 20
Loss 4.180748146609403e-05, train accuracy 0.9994459833795014, val accuracy
0.9130434782608695
Iteration 1108, epoch 20
Loss 9.348192179459147e-06, train accuracy 0.9994459833795014, val accuracy
0.9130434782608695
Iteration 1109, epoch 20
Loss 1.3203158232499845e-05, train accuracy 0.9994459833795014, val accuracy
0.9130434782608695
Iteration 1110, epoch 20
Loss 1.8704309695749544e-05, train accuracy 0.9994459833795014, val accuracy
0.9178743961352657
Iteration 1111, epoch 20
Loss 1.2185274499643128e-05, train accuracy 0.9994459833795014, val accuracy
0.9178743961352657
Iteration 1112, epoch 20
Loss 8.436179996351711e-06, train accuracy 0.9994459833795014, val accuracy
0.9178743961352657
Iteration 1113, epoch 20
Loss 8.596032785135321e-06, train accuracy 0.9994459833795014, val accuracy
0.9178743961352657
Iteration 1114, epoch 20
Loss 2.067147033812944e-05, train accuracy 0.9994459833795014, val accuracy
0.9178743961352657
Iteration 1115, epoch 20
Loss 1.4101321539783385e-05, train accuracy 0.9994459833795014, val accuracy
0.9178743961352657
Iteration 1116, epoch 20
Loss 4.584898124448955e-05, train accuracy 0.9994459833795014, val accuracy
0.9178743961352657
Iteration 1117, epoch 20
Loss 4.428240572451614e-05, train accuracy 0.9994459833795014, val accuracy
0.9178743961352657
Iteration 1118, epoch 20
Loss 1.4052559890842531e-05, train accuracy 0.9994459833795014, val accuracy
0.9178743961352657
Iteration 1119, epoch 20
Loss 9.443710951018147e-06, train accuracy 0.9994459833795014, val accuracy
0.9178743961352657
Iteration 1120, epoch 20
Loss 4.687629825639306e-06, train accuracy 0.9994459833795014, val accuracy
0.9178743961352657
```

```
Iteration 1121, epoch 20
Loss 1.2765968676831108e-05, train accuracy 0.9994459833795014, val accuracy
0.9227053140096618
Iteration 1122, epoch 20
Loss 0.003059645416215062, train accuracy 0.9994459833795014, val accuracy 0.
9227053140096618
Iteration 1123, epoch 20
Loss 2.5814260879997164e-05, train accuracy 0.9994459833795014, val accuracy
0.9178743961352657
Iteration 1124, epoch 20
Loss 1.2601851267390884e-05, train accuracy 0.9994459833795014, val accuracy
0.9178743961352657
Iteration 1125, epoch 20
Loss 2.4035431124502793e-05, train accuracy 0.9994459833795014, val accuracy
0.9130434782608695
Iteration 1126, epoch 20
Loss 6.976575605222024e-06, train accuracy 0.9994459833795014, val accuracy
0.9130434782608695
Iteration 1127, epoch 20
Loss 6.085035238356795e-06, train accuracy 0.9994459833795014, val accuracy
0.9178743961352657
Iteration 1128, epoch 20
Loss 3.700312663568184e-05, train accuracy 0.9994459833795014, val accuracy
0.9178743961352657
Iteration 1129, epoch 20
Loss 1.4955950973671861e-05, train accuracy 0.9994459833795014, val accuracy
0.9178743961352657
Iteration 1130, epoch 20
Loss 1.4325799384096172e-05, train accuracy 0.9994459833795014, val accuracy
0.9178743961352657
Iteration 1131, epoch 20
Loss 5.477496233652346e-05, train accuracy 0.9994459833795014, val accuracy
0.9227053140096618
Iteration 1132, epoch 20
Loss 2.0605311874533072e-05, train accuracy 0.9994459833795014, val accuracy
0.9227053140096618
Iteration 1133, epoch 20
Loss 0.0016777345445007086, train accuracy 0.9994459833795014, val accuracy
0.9227053140096618
Iteration 1134, epoch 20
Loss 6.675354597973637e-06, train accuracy 0.9994459833795014, val accuracy
0.9227053140096618
Iteration 1135, epoch 20
Loss 3.1115050660446286e-05, train accuracy 0.9994459833795014, val accuracy
0.9227053140096618
Iteration 1136, epoch 20
Loss 1.333328600594541e-05, train accuracy 0.9994459833795014, val accuracy
0.9227053140096618
Iteration 1137, epoch 20
Loss 2.366932312725112e-05, train accuracy 0.9994459833795014, val accuracy
0.9227053140096618
Iteration 1138, epoch 20
Loss 1.4686166650790256e-05, train accuracy 0.9994459833795014, val accuracy
0.9227053140096618
Iteration 1139, epoch 20
Loss 1.2401307825572216e-05, train accuracy 0.9994459833795014, val accuracy
0.9227053140096618
```






```
Final training accuracy: 0.9994459833795014
Final validation accuracy: 0.9227053140096618
```

Part (d) - 2 pt

Report the test accuracy of your best model. How does the test accuracy compare to Part 3(d) without transfer learning?

In [44]:
```
# Create model
alexnet_classifier = Classifier()
state = torch.load(f"CNN_epoch_{19}")
alexnet_classifier.load_state_dict(state)
alexnet_classifier.to(device)

# Create dataset
testing_features = np.load("./testing_alexdata.npy")
testing_labels = np.load("./testing_labels.npy")

testing_set = Dataset(testing_features, testing_labels)

# Create dataloader
testing_set = DataLoader(testing_set, batch_size=32, shuffle=True)

# Calculate accuracy
accuracy = calc_acc(alexnet_classifier, testing_set)
print(f"The test accuracy of the alexnet classifier is {accuracy}")
```

```
The test accuracy of the alexnet classifier is 0.9227053140096618
```

The test accuracy of this section is much higher than the test accuracy of the basic CNN created above.

5. Additional Testing [5 pt]

As a final step in testing we will be revisiting the sample images that you had collected and submitted at the start of this lab. These sample images should be untouched and will be used to demonstrate how well your model works at identifying your hand guestures.

Using the best transfer learning model developed in Part 4. Report the test accuracy on your sample images and how it compares to the test accuracy obtained in Part 4(d)? How well did your model do for the different hand guestures? Provide an explanation for why you think your model performed the way it did?

In [47]:
```
##### USED DATA FROM 2C BASED ON ANSWERS TO PIAZZA POSTS #####

# Create model
alexnet_classifier = Classifier()
state = torch.load(f"CNN_epoch_{19}")
alexnet_classifier.load_state_dict(state)
alexnet_classifier.to(device)

# Create dataset
temp = np.moveaxis(np.load("./testing_data_2c.npy"), -1, 1)
data_prep_alex(temp, "testing_2c")
testing_features = np.load("./testing_2c_alexdata.npy")
testing_labels = np.load("./testing_labels_2c.npy")

testing_set = Dataset(testing_features, testing_labels)

# Create dataloader
testing_set = DataLoader(testing_set, batch_size=32, shuffle=True)

# Calculate accuracy
accuracy = calc_acc(alexnet_classifier, testing_set)
print(f"The test accuracy of the alexnet classifier is {accuracy}")
```

```
The test accuracy of the alexnet classifier is 0.9876543209876543
```

The test accuracy of my best alexnet classifier is 0.9876. This accuracy is much higher than the test accuracy from part 4d. I think this difference occurs because the size of the test set from part 2c is very small, so the accuracy may vary a lot for every correct/wrong prediction and may not be a good indicator of how the model actually performs.