HW4

1-Multi-Layer Perceptron

In [2]:
```
# import tensorflow as tf
import tensorflow.compat.v1 as tf
tf.disable_v2_behavior()
import matplotlib.pyplot as plt
from tensorflow.keras.datasets import cifar10
from tensorflow.keras.utils import to_categorical
import numpy as np
```

In [2]:
```
# tf.test.is_gpu_available(
#     cuda_only=False, min_cuda_compute_capability=None
# )
```

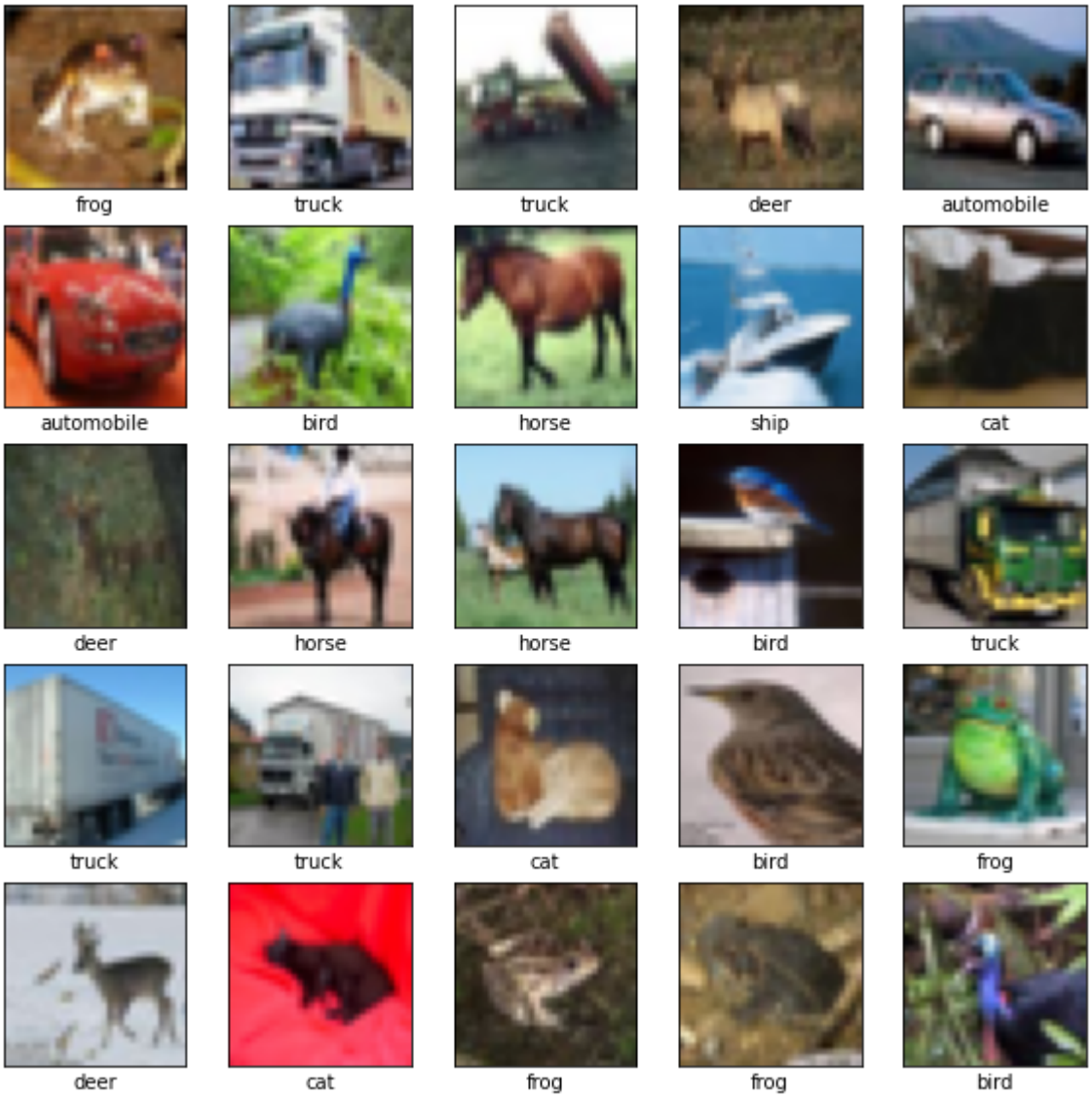
In [4]:
```
#Load the data
(x_train, y_train), (x_test, y_test) = cifar10.load_data()
```

In [5]:
```
#define class names
class_names = ['airplane', 'automobile', 'bird', 'cat', 'deer',
               'dog', 'frog', 'horse', 'ship', 'truck']
```

In [6]:
```
print('Train', x_train.shape, y_train.shape)
print('Test', (x_test.shape, y_test.shape))
# normalize pixel values
x_train, x_test = x_train/255, x_test/255
```

```
Train (50000, 32, 32, 3) (50000, 1)
Test ((10000, 32, 32, 3), (10000, 1))
```

In [7]:
```
#Plot some of the images
plt.figure(figsize=(10,10))
for i in range(25):
    plt.subplot(5,5,i+1)
    plt.xticks([])
    plt.yticks([])
    plt.grid(False)
    plt.imshow(x_train[i], cmap=plt.cm.binary)
    # The CIFAR labels happen to be arrays,
    # which is why you need the extra index
    plt.xlabel(class_names[y_train[i][0]])
plt.show()
```



In [8]:
```
#flatting the training data to (50000*3072)
#where 3072 = 32*32*3
# u = x_train.reshape(-1, 3072)
x_train = x_train.reshape(x_train.shape[0], x_train.shape[1]*x_train.shape[2]*x_
x_test = x_test.reshape(x_test.shape[0], x_test.shape[1]*x_test.shape[2]*x_test.
```

In [9]:
```
#One Hot Encode with Keras for the labels
y_train = to_categorical(y_train)
y_test = to_categorical(y_test)
```

In [11]:
```
#Randomize the data
def  shuffle_data(x, y):
    permutation = np.random.permutation(x.shape[0])
    shuffled_x, shuffled_y  = x[permutation], y[permutation]
    return shuffled_x, shuffled_y

def get_next_batch(x, y, start, end):
    x_batch, y_batch = x[start:end], y[start:end]
    return x_batch, y_batch
```

In [12]:
```
# weight and bais wrappers
def weight_variable(name, shape):
    """
    Create a weight variable with appropriate initialization
    :param name: weight name
    :param shape: weight shape
    :return: initialized weight variable
    """
    initer = tf.truncated_normal_initializer(stddev=0.01)
    return tf.get_variable('W_' + name,
                           dtype=tf.float32,
                           shape=shape,
                           initializer=initer)
```

In [13]:
```
def bias_variable(name, shape):
    """
    Create a bias variable with appropriate initialization
    :param name: bias variable name
    :param shape: bias variable shape
    :return: initialized bias variable
    """
    initial = tf.constant(0., shape=shape, dtype=tf.float32)
    return tf.get_variable('b_' + name,
                           dtype=tf.float32,
                           initializer=initial)
```

In [ ]:
```
# weights and bias for layer 1
w1 =
```

In [14]:
```
def layer(x, num_units, name, use_relu=True):
    """
    Create a fully-connected layer
    :param x: input from previous layer
    :param num_units: number of hidden units in the fully-connected layer
    :param name: layer name
    :param use_relu: boolean to add ReLU non-linearity (or not)
    :return: The output array
    """
    in_dim = x.get_shape()[1]
    W = weight_variable(name, shape=[in_dim, num_units])
    b = bias_variable(name, [num_units])
    layer = tf.matmul(x, W)
    layer += b
    if use_relu:
        layer = tf.nn.relu(layer)
    return layer, W
```

In [60]:
```
#Network configuration
h1 = 50 #250                 # Number of nodes in the first hidden layer
h2 = 50 #250                    # Number of nodes in the second hidden layer
#input vector size
feature_vector_size = x_train.shape[1]
num_classes = len(class_names)
```

In [61]:
```
# Parameters
learning_rate = 0.001  # The optimization initial learning rate
epochs = 50            # Total number of training epochs
batch_size = 100       # Training batch size
display_freq = 100       # Frequency of displaying the training results
```

In [62]:
```
# Remove previous weights, bias, inputs, etc..
tf.reset_default_graph()
```

In [63]:
```
#creating the network
# Create the graph for the linear model
# Placeholders for inputs (x) and outputs(y)
x = tf.placeholder(tf.float32, shape=[None, feature_vector_size], name='X')
y = tf.placeholder(tf.float32, shape=[None, num_classes], name='Y')
```

In [64]:
```

```

Out[64]:
```
Dimension(3072)
```

In [65]:
```
#Create the network layers
layer_h1, hidden_weights_1 = fc_layer(x, 250, 'FC1', use_relu=True)
# layer_h2, hidden_weights_2 = fc_layer(layer_h1, 768, 'FC2', use_relu=True)
# layer_h3, hidden_weights_3 = fc_layer(layer_h2, 384, 'FC3', use_relu=True)
# layer_h4, hidden_weights_4 = fc_layer(layer_h3, 128, 'FC4', use_relu=True)
output_logits, hidden_weights_out = fc_layer(layer_h1, num_classes, 'OUT', use_r
```

In [66]:
```
# Network predictions
cls_prediction = tf.argmax(output_logits, axis=1, name='predictions')

#the loss function, optimizer, accuracy, and predicted class
# loss = tf.reduce_mean(tf.nn.softmax_cross_entropy_with_logits(labels=y, logits
# Loss function using L2 Regularization
loss = (tf.reduce_mean(tf.nn.softmax_cross_entropy_with_logits(labels=y, logits=
       0.01*tf.nn.l2_loss(hidden_weights_1) + \
#        0.01*tf.nn.l2_loss(hidden_weights_2) + \
#        0.01*tf.nn.l2_loss(hidden_weights_3) + \
#        0.01*tf.nn.l2_loss(hidden_weights_4) + \
       0.01*tf.nn.l2_loss(hidden_weights_out))


optimizer = tf.train.AdamOptimizer(learning_rate=learning_rate, name='Adam-op').
# optimizer = tf.train.GradientDescentOptimizer(learning_rate = learning_rate).m

correct_prediction = tf.equal(tf.argmax(output_logits, 1), tf.argmax(y, 1), name
accuracy = tf.reduce_mean(tf.cast(correct_prediction, tf.float32), name='accurac
```

In [67]:
```
# Create the op for initializing all variables
init = tf.global_variables_initializer()
```

In [68]:
```
#train
sess = tf.InteractiveSession()
```

```
sess.run(init)
global_step = 0
# Number of training iterations in each epoch
num_tr_iter = int(len(y_train) / batch_size)
```

In [69]:

```
for epoch in range(epochs):
    print('Training epoch: {}'.format(epoch + 1))
    x_train, y_train = randomize(x_train, y_train)
    for iteration in range(num_tr_iter):
        global_step += 1
        start = iteration * batch_size
        end = (iteration + 1) * batch_size
        x_batch, y_batch = get_next_batch(x_train, y_train, start, end)

        # Run optimization op (backprop)
        feed_dict_batch = {x: x_batch, y: y_batch}
        sess.run(optimizer, feed_dict=feed_dict_batch)

        if iteration % display_freq == 0:
            # Calculate and display the batch loss and accuracy
            loss_batch, acc_batch = sess.run([loss, accuracy],
                                             feed_dict=feed_dict_batch)

            print("iter {0:3d}:\t Loss={1:.2f},\tTraining Accuracy={2:.01%}".
                  format(iteration, loss_batch, acc_batch))

    # Run validation after every epoch
    feed_dict_valid = {x: x_test[:1000], y: y_test[:1000]}
    loss_valid, acc_valid = sess.run([loss, accuracy], feed_dict=feed_dict_valid
    print('---------------------------------------------------------')
    print("Epoch: {0}, validation loss: {1:.2f}, validation accuracy: {2:.01%}".
          format(epoch + 1, loss_valid, acc_valid))
    print('---------------------------------------------------------')
```

```
Training epoch: 1
iter   0:        Loss=2.52,     Training Accuracy=22.0%
iter 100:        Loss=2.05,     Training Accuracy=34.0%
iter 200:        Loss=2.02,     Training Accuracy=28.0%
iter 300:        Loss=1.93,     Training Accuracy=35.0%
iter 400:        Loss=1.89,     Training Accuracy=35.0%
---------------------------------------------------------
Epoch: 1, validation loss: 1.95, validation accuracy: 33.8%
---------------------------------------------------------
Training epoch: 2
iter   0:        Loss=1.98,     Training Accuracy=39.0%
iter 100:        Loss=1.74,     Training Accuracy=47.0%
iter 200:        Loss=1.90,     Training Accuracy=37.0%
iter 300:        Loss=1.89,     Training Accuracy=30.0%
iter 400:        Loss=2.00,     Training Accuracy=27.0%
---------------------------------------------------------
Epoch: 2, validation loss: 1.93, validation accuracy: 33.7%
---------------------------------------------------------
Training epoch: 3
iter   0:        Loss=1.91,     Training Accuracy=38.0%
iter 100:        Loss=1.79,     Training Accuracy=37.0%
iter 200:        Loss=1.95,     Training Accuracy=29.0%
iter 300:        Loss=1.78,     Training Accuracy=41.0%
iter 400:        Loss=1.79,     Training Accuracy=44.0%
---------------------------------------------------------
Epoch: 3, validation loss: 1.86, validation accuracy: 36.4%
```

```
------------------------------------------------------------
Training epoch: 4
iter   0:        Loss=1.73,     Training Accuracy=46.0%
iter 100:        Loss=1.91,     Training Accuracy=33.0%
iter 200:        Loss=1.80,     Training Accuracy=33.0%
iter 300:        Loss=1.82,     Training Accuracy=42.0%
iter 400:        Loss=1.77,     Training Accuracy=37.0%
------------------------------------------------------------
Epoch: 4, validation loss: 1.83, validation accuracy: 37.7%
------------------------------------------------------------
Training epoch: 5
iter   0:        Loss=1.85,     Training Accuracy=41.0%
iter 100:        Loss=1.63,     Training Accuracy=55.0%
iter 200:        Loss=1.67,     Training Accuracy=42.0%
iter 300:        Loss=1.69,     Training Accuracy=41.0%
iter 400:        Loss=1.74,     Training Accuracy=41.0%
------------------------------------------------------------
Epoch: 5, validation loss: 1.83, validation accuracy: 37.9%
------------------------------------------------------------
Training epoch: 6
iter   0:        Loss=1.79,     Training Accuracy=42.0%
iter 100:        Loss=1.70,     Training Accuracy=47.0%
iter 200:        Loss=1.78,     Training Accuracy=37.0%
iter 300:        Loss=1.67,     Training Accuracy=44.0%
iter 400:        Loss=1.73,     Training Accuracy=38.0%
------------------------------------------------------------
Epoch: 6, validation loss: 1.78, validation accuracy: 39.8%
------------------------------------------------------------
Training epoch: 7
iter   0:        Loss=1.83,     Training Accuracy=36.0%
iter 100:        Loss=1.80,     Training Accuracy=34.0%
iter 200:        Loss=1.67,     Training Accuracy=49.0%
iter 300:        Loss=1.60,     Training Accuracy=55.0%
iter 400:        Loss=1.71,     Training Accuracy=43.0%
------------------------------------------------------------
Epoch: 7, validation loss: 1.80, validation accuracy: 39.9%
------------------------------------------------------------
Training epoch: 8
iter   0:        Loss=1.84,     Training Accuracy=34.0%
iter 100:        Loss=1.67,     Training Accuracy=46.0%
iter 200:        Loss=1.72,     Training Accuracy=40.0%
iter 300:        Loss=1.87,     Training Accuracy=42.0%
iter 400:        Loss=1.74,     Training Accuracy=44.0%
------------------------------------------------------------
Epoch: 8, validation loss: 1.86, validation accuracy: 36.3%
------------------------------------------------------------
Training epoch: 9
iter   0:        Loss=1.80,     Training Accuracy=36.0%
iter 100:        Loss=1.85,     Training Accuracy=45.0%
iter 200:        Loss=1.55,     Training Accuracy=49.0%
iter 300:        Loss=1.93,     Training Accuracy=32.0%
iter 400:        Loss=1.72,     Training Accuracy=43.0%
------------------------------------------------------------
Epoch: 9, validation loss: 1.80, validation accuracy: 38.3%
------------------------------------------------------------
Training epoch: 10
iter   0:        Loss=1.71,     Training Accuracy=43.0%
iter 100:        Loss=1.86,     Training Accuracy=40.0%
iter 200:        Loss=1.65,     Training Accuracy=48.0%
iter 300:        Loss=1.71,     Training Accuracy=48.0%
iter 400:        Loss=1.85,     Training Accuracy=35.0%
------------------------------------------------------------
Epoch: 10, validation loss: 1.78, validation accuracy: 39.8%
------------------------------------------------------------
Training epoch: 11
```

```
iter   0:        Loss=1.81,     Training Accuracy=41.0%
iter 100:        Loss=1.84,     Training Accuracy=41.0%
iter 200:        Loss=1.77,     Training Accuracy=35.0%
iter 300:        Loss=1.73,     Training Accuracy=43.0%
iter 400:        Loss=1.70,     Training Accuracy=42.0%
------------------------------------------------------------
Epoch: 11, validation loss: 1.77, validation accuracy: 40.4%
------------------------------------------------------------
Training epoch: 12
iter   0:        Loss=1.67,     Training Accuracy=43.0%
iter 100:        Loss=1.76,     Training Accuracy=47.0%
iter 200:        Loss=1.62,     Training Accuracy=41.0%
iter 300:        Loss=1.76,     Training Accuracy=41.0%
iter 400:        Loss=1.70,     Training Accuracy=51.0%
------------------------------------------------------------
Epoch: 12, validation loss: 1.79, validation accuracy: 39.9%
------------------------------------------------------------
Training epoch: 13
iter   0:        Loss=1.65,     Training Accuracy=43.0%
iter 100:        Loss=1.81,     Training Accuracy=41.0%
iter 200:        Loss=1.69,     Training Accuracy=39.0%
iter 300:        Loss=1.73,     Training Accuracy=42.0%
iter 400:        Loss=1.69,     Training Accuracy=47.0%
------------------------------------------------------------
Epoch: 13, validation loss: 1.79, validation accuracy: 40.5%
------------------------------------------------------------
Training epoch: 14
iter   0:        Loss=1.80,     Training Accuracy=44.0%
iter 100:        Loss=1.80,     Training Accuracy=39.0%
iter 200:        Loss=1.72,     Training Accuracy=44.0%
iter 300:        Loss=1.70,     Training Accuracy=44.0%
iter 400:        Loss=1.69,     Training Accuracy=42.0%
------------------------------------------------------------
Epoch: 14, validation loss: 1.77, validation accuracy: 41.8%
------------------------------------------------------------
Training epoch: 15
iter   0:        Loss=1.81,     Training Accuracy=38.0%
iter 100:        Loss=1.85,     Training Accuracy=32.0%
iter 200:        Loss=1.67,     Training Accuracy=45.0%
iter 300:        Loss=1.86,     Training Accuracy=38.0%
iter 400:        Loss=1.83,     Training Accuracy=46.0%
------------------------------------------------------------
Epoch: 15, validation loss: 1.81, validation accuracy: 39.0%
------------------------------------------------------------
Training epoch: 16
iter   0:        Loss=1.61,     Training Accuracy=47.0%
iter 100:        Loss=1.80,     Training Accuracy=38.0%
iter 200:        Loss=1.90,     Training Accuracy=36.0%
iter 300:        Loss=1.74,     Training Accuracy=39.0%
iter 400:        Loss=1.60,     Training Accuracy=47.0%
------------------------------------------------------------
Epoch: 16, validation loss: 1.77, validation accuracy: 39.1%
------------------------------------------------------------
Training epoch: 17
iter   0:        Loss=1.69,     Training Accuracy=45.0%
iter 100:        Loss=1.96,     Training Accuracy=32.0%
iter 200:        Loss=1.80,     Training Accuracy=42.0%
iter 300:        Loss=1.80,     Training Accuracy=40.0%
iter 400:        Loss=1.65,     Training Accuracy=46.0%
------------------------------------------------------------
Epoch: 17, validation loss: 1.82, validation accuracy: 37.2%
------------------------------------------------------------
Training epoch: 18
iter   0:        Loss=1.68,     Training Accuracy=43.0%
iter 100:        Loss=1.71,     Training Accuracy=42.0%
```

```
iter 200:        Loss=1.70,     Training Accuracy=47.0%
iter 300:        Loss=1.75,     Training Accuracy=46.0%
iter 400:        Loss=1.78,     Training Accuracy=42.0%
-------------------------------------------------------
Epoch: 18, validation loss: 1.76, validation accuracy: 40.5%
-------------------------------------------------------
Training epoch: 19
iter   0:        Loss=1.77,     Training Accuracy=34.0%
iter 100:        Loss=1.72,     Training Accuracy=40.0%
iter 200:        Loss=1.63,     Training Accuracy=48.0%
iter 300:        Loss=1.70,     Training Accuracy=44.0%
iter 400:        Loss=1.52,     Training Accuracy=52.0%
-------------------------------------------------------
Epoch: 19, validation loss: 1.80, validation accuracy: 40.5%
-------------------------------------------------------
Training epoch: 20
iter   0:        Loss=1.71,     Training Accuracy=41.0%
iter 100:        Loss=1.69,     Training Accuracy=47.0%
iter 200:        Loss=1.80,     Training Accuracy=40.0%
iter 300:        Loss=1.77,     Training Accuracy=39.0%
iter 400:        Loss=1.72,     Training Accuracy=43.0%
-------------------------------------------------------
Epoch: 20, validation loss: 1.78, validation accuracy: 42.0%
-------------------------------------------------------
Training epoch: 21
iter   0:        Loss=1.72,     Training Accuracy=40.0%
iter 100:        Loss=1.70,     Training Accuracy=48.0%
iter 200:        Loss=1.78,     Training Accuracy=38.0%
iter 300:        Loss=1.59,     Training Accuracy=48.0%
iter 400:        Loss=1.73,     Training Accuracy=38.0%
-------------------------------------------------------
Epoch: 21, validation loss: 1.76, validation accuracy: 41.8%
-------------------------------------------------------
Training epoch: 22
iter   0:        Loss=1.81,     Training Accuracy=40.0%
iter 100:        Loss=1.66,     Training Accuracy=47.0%
iter 200:        Loss=1.75,     Training Accuracy=44.0%
iter 300:        Loss=1.70,     Training Accuracy=40.0%
iter 400:        Loss=1.76,     Training Accuracy=42.0%
-------------------------------------------------------
Epoch: 22, validation loss: 1.75, validation accuracy: 43.0%
-------------------------------------------------------
Training epoch: 23
iter   0:        Loss=1.71,     Training Accuracy=44.0%
iter 100:        Loss=1.74,     Training Accuracy=42.0%
iter 200:        Loss=1.68,     Training Accuracy=48.0%
iter 300:        Loss=1.82,     Training Accuracy=36.0%
iter 400:        Loss=1.71,     Training Accuracy=40.0%
-------------------------------------------------------
Epoch: 23, validation loss: 1.74, validation accuracy: 40.4%
-------------------------------------------------------
Training epoch: 24
iter   0:        Loss=1.75,     Training Accuracy=44.0%
iter 100:        Loss=1.89,     Training Accuracy=39.0%
iter 200:        Loss=1.51,     Training Accuracy=50.0%
iter 300:        Loss=1.66,     Training Accuracy=42.0%
iter 400:        Loss=1.88,     Training Accuracy=41.0%
-------------------------------------------------------
Epoch: 24, validation loss: 1.78, validation accuracy: 40.4%
-------------------------------------------------------
Training epoch: 25
iter   0:        Loss=1.65,     Training Accuracy=48.0%
iter 100:        Loss=1.77,     Training Accuracy=36.0%
iter 200:        Loss=1.65,     Training Accuracy=48.0%
iter 300:        Loss=1.80,     Training Accuracy=43.0%
```

```
iter 400:        Loss=1.79,     Training Accuracy=38.0%
------------------------------------------------------------
Epoch: 25, validation loss: 1.81, validation accuracy: 40.6%
------------------------------------------------------------
Training epoch: 26
iter   0:        Loss=1.66,     Training Accuracy=46.0%
iter 100:        Loss=1.95,     Training Accuracy=38.0%
iter 200:        Loss=1.74,     Training Accuracy=42.0%
iter 300:        Loss=1.75,     Training Accuracy=44.0%
iter 400:        Loss=1.83,     Training Accuracy=39.0%
------------------------------------------------------------
Epoch: 26, validation loss: 1.84, validation accuracy: 39.1%
------------------------------------------------------------
Training epoch: 27
iter   0:        Loss=1.83,     Training Accuracy=39.0%
iter 100:        Loss=1.76,     Training Accuracy=46.0%
iter 200:        Loss=1.76,     Training Accuracy=41.0%
iter 300:        Loss=1.72,     Training Accuracy=47.0%
iter 400:        Loss=1.73,     Training Accuracy=43.0%
------------------------------------------------------------
Epoch: 27, validation loss: 1.73, validation accuracy: 43.0%
------------------------------------------------------------
Training epoch: 28
iter   0:        Loss=1.71,     Training Accuracy=48.0%
iter 100:        Loss=1.75,     Training Accuracy=44.0%
iter 200:        Loss=1.88,     Training Accuracy=47.0%
iter 300:        Loss=1.64,     Training Accuracy=52.0%
iter 400:        Loss=1.63,     Training Accuracy=49.0%
------------------------------------------------------------
Epoch: 28, validation loss: 1.76, validation accuracy: 43.3%
------------------------------------------------------------
Training epoch: 29
iter   0:        Loss=1.90,     Training Accuracy=35.0%
iter 100:        Loss=1.76,     Training Accuracy=48.0%
iter 200:        Loss=1.74,     Training Accuracy=38.0%
iter 300:        Loss=1.88,     Training Accuracy=34.0%
iter 400:        Loss=1.66,     Training Accuracy=47.0%
------------------------------------------------------------
Epoch: 29, validation loss: 1.78, validation accuracy: 39.6%
------------------------------------------------------------
Training epoch: 30
iter   0:        Loss=1.67,     Training Accuracy=46.0%
iter 100:        Loss=1.83,     Training Accuracy=47.0%
iter 200:        Loss=1.83,     Training Accuracy=35.0%
iter 300:        Loss=1.56,     Training Accuracy=48.0%
iter 400:        Loss=1.73,     Training Accuracy=40.0%
------------------------------------------------------------
Epoch: 30, validation loss: 1.80, validation accuracy: 40.4%
------------------------------------------------------------
Training epoch: 31
iter   0:        Loss=1.64,     Training Accuracy=44.0%
iter 100:        Loss=1.78,     Training Accuracy=41.0%
iter 200:        Loss=1.87,     Training Accuracy=36.0%
iter 300:        Loss=1.73,     Training Accuracy=42.0%
iter 400:        Loss=1.87,     Training Accuracy=38.0%
------------------------------------------------------------
Epoch: 31, validation loss: 1.76, validation accuracy: 42.6%
------------------------------------------------------------
Training epoch: 32
iter   0:        Loss=1.78,     Training Accuracy=42.0%
iter 100:        Loss=1.87,     Training Accuracy=33.0%
iter 200:        Loss=1.68,     Training Accuracy=52.0%
iter 300:        Loss=1.74,     Training Accuracy=43.0%
iter 400:        Loss=1.73,     Training Accuracy=39.0%
------------------------------------------------------------
```

```
Epoch: 32, validation loss: 1.77, validation accuracy: 40.1%
-------------------------------------------------------
Training epoch: 33
iter   0:        Loss=1.86,     Training Accuracy=44.0%
iter 100:        Loss=1.70,     Training Accuracy=49.0%
iter 200:        Loss=1.76,     Training Accuracy=41.0%
iter 300:        Loss=1.71,     Training Accuracy=46.0%
iter 400:        Loss=1.70,     Training Accuracy=45.0%
-------------------------------------------------------
Epoch: 33, validation loss: 1.75, validation accuracy: 42.3%
-------------------------------------------------------
Training epoch: 34
iter   0:        Loss=1.77,     Training Accuracy=42.0%
iter 100:        Loss=1.78,     Training Accuracy=39.0%
iter 200:        Loss=1.73,     Training Accuracy=49.0%
iter 300:        Loss=1.66,     Training Accuracy=44.0%
iter 400:        Loss=1.81,     Training Accuracy=40.0%
-------------------------------------------------------
Epoch: 34, validation loss: 1.75, validation accuracy: 41.8%
-------------------------------------------------------
Training epoch: 35
iter   0:        Loss=1.69,     Training Accuracy=51.0%
iter 100:        Loss=1.71,     Training Accuracy=48.0%
iter 200:        Loss=1.87,     Training Accuracy=35.0%
iter 300:        Loss=1.74,     Training Accuracy=39.0%
iter 400:        Loss=1.81,     Training Accuracy=43.0%
-------------------------------------------------------
Epoch: 35, validation loss: 1.77, validation accuracy: 41.5%
-------------------------------------------------------
Training epoch: 36
iter   0:        Loss=1.80,     Training Accuracy=43.0%
iter 100:        Loss=1.72,     Training Accuracy=38.0%
iter 200:        Loss=1.77,     Training Accuracy=47.0%
iter 300:        Loss=1.57,     Training Accuracy=50.0%
iter 400:        Loss=1.73,     Training Accuracy=42.0%
-------------------------------------------------------
Epoch: 36, validation loss: 1.72, validation accuracy: 44.1%
-------------------------------------------------------
Training epoch: 37
iter   0:        Loss=1.75,     Training Accuracy=40.0%
iter 100:        Loss=1.81,     Training Accuracy=36.0%
iter 200:        Loss=1.71,     Training Accuracy=50.0%
iter 300:        Loss=1.70,     Training Accuracy=44.0%
iter 400:        Loss=1.70,     Training Accuracy=43.0%
-------------------------------------------------------
Epoch: 37, validation loss: 1.81, validation accuracy: 41.4%
-------------------------------------------------------
Training epoch: 38
iter   0:        Loss=1.74,     Training Accuracy=42.0%
iter 100:        Loss=1.76,     Training Accuracy=42.0%
iter 200:        Loss=1.70,     Training Accuracy=40.0%
iter 300:        Loss=1.77,     Training Accuracy=46.0%
iter 400:        Loss=1.76,     Training Accuracy=44.0%
-------------------------------------------------------
Epoch: 38, validation loss: 1.78, validation accuracy: 42.2%
-------------------------------------------------------
Training epoch: 39
iter   0:        Loss=1.68,     Training Accuracy=44.0%
iter 100:        Loss=1.74,     Training Accuracy=44.0%
iter 200:        Loss=1.68,     Training Accuracy=44.0%
iter 300:        Loss=1.63,     Training Accuracy=38.0%
iter 400:        Loss=1.77,     Training Accuracy=41.0%
-------------------------------------------------------
Epoch: 39, validation loss: 1.74, validation accuracy: 42.5%
-------------------------------------------------------
```

```
Training epoch: 40
iter   0:        Loss=1.74,     Training Accuracy=42.0%
iter 100:        Loss=1.76,     Training Accuracy=37.0%
iter 200:        Loss=1.71,     Training Accuracy=40.0%
iter 300:        Loss=1.58,     Training Accuracy=49.0%
iter 400:        Loss=1.73,     Training Accuracy=40.0%
------------------------------------------------------------
Epoch: 40, validation loss: 1.74, validation accuracy: 42.5%
------------------------------------------------------------
Training epoch: 41
iter   0:        Loss=1.80,     Training Accuracy=38.0%
iter 100:        Loss=1.89,     Training Accuracy=34.0%
iter 200:        Loss=1.72,     Training Accuracy=39.0%
iter 300:        Loss=1.82,     Training Accuracy=45.0%
iter 400:        Loss=1.71,     Training Accuracy=51.0%
------------------------------------------------------------
Epoch: 41, validation loss: 1.76, validation accuracy: 41.2%
------------------------------------------------------------
Training epoch: 42
iter   0:        Loss=1.66,     Training Accuracy=48.0%
iter 100:        Loss=1.65,     Training Accuracy=44.0%
iter 200:        Loss=1.66,     Training Accuracy=49.0%
iter 300:        Loss=1.54,     Training Accuracy=49.0%
iter 400:        Loss=1.79,     Training Accuracy=43.0%
------------------------------------------------------------
Epoch: 42, validation loss: 1.77, validation accuracy: 38.7%
------------------------------------------------------------
Training epoch: 43
iter   0:        Loss=1.78,     Training Accuracy=46.0%
iter 100:        Loss=1.83,     Training Accuracy=38.0%
iter 200:        Loss=1.67,     Training Accuracy=45.0%
iter 300:        Loss=1.62,     Training Accuracy=47.0%
iter 400:        Loss=1.75,     Training Accuracy=43.0%
------------------------------------------------------------
Epoch: 43, validation loss: 1.79, validation accuracy: 40.2%
------------------------------------------------------------
Training epoch: 44
iter   0:        Loss=1.70,     Training Accuracy=44.0%
iter 100:        Loss=1.76,     Training Accuracy=48.0%
iter 200:        Loss=1.72,     Training Accuracy=47.0%
iter 300:        Loss=1.87,     Training Accuracy=41.0%
iter 400:        Loss=1.85,     Training Accuracy=41.0%
------------------------------------------------------------
Epoch: 44, validation loss: 1.76, validation accuracy: 42.2%
------------------------------------------------------------
Training epoch: 45
iter   0:        Loss=1.74,     Training Accuracy=49.0%
iter 100:        Loss=1.75,     Training Accuracy=45.0%
iter 200:        Loss=1.86,     Training Accuracy=41.0%
iter 300:        Loss=1.69,     Training Accuracy=46.0%
iter 400:        Loss=1.70,     Training Accuracy=45.0%
------------------------------------------------------------
Epoch: 45, validation loss: 1.72, validation accuracy: 41.3%
------------------------------------------------------------
Training epoch: 46
iter   0:        Loss=1.71,     Training Accuracy=42.0%
iter 100:        Loss=1.71,     Training Accuracy=44.0%
iter 200:        Loss=1.77,     Training Accuracy=43.0%
iter 300:        Loss=1.87,     Training Accuracy=41.0%
iter 400:        Loss=1.80,     Training Accuracy=39.0%
------------------------------------------------------------
Epoch: 46, validation loss: 1.76, validation accuracy: 41.9%
------------------------------------------------------------
Training epoch: 47
iter   0:        Loss=1.58,     Training Accuracy=44.0%
```

```
iter 100:        Loss=1.72,     Training Accuracy=38.0%
iter 200:        Loss=1.77,     Training Accuracy=41.0%
iter 300:        Loss=1.74,     Training Accuracy=43.0%
iter 400:        Loss=1.76,     Training Accuracy=39.0%
----------------------------------------------------------
Epoch: 47, validation loss: 1.75, validation accuracy: 42.4%
----------------------------------------------------------
Training epoch: 48
iter   0:        Loss=1.76,     Training Accuracy=38.0%
iter 100:        Loss=1.78,     Training Accuracy=48.0%
iter 200:        Loss=1.77,     Training Accuracy=38.0%
iter 300:        Loss=1.65,     Training Accuracy=50.0%
iter 400:        Loss=1.68,     Training Accuracy=40.0%
----------------------------------------------------------
Epoch: 48, validation loss: 1.79, validation accuracy: 40.2%
----------------------------------------------------------
Training epoch: 49
iter   0:        Loss=1.68,     Training Accuracy=41.0%
iter 100:        Loss=1.72,     Training Accuracy=41.0%
iter 200:        Loss=1.55,     Training Accuracy=49.0%
iter 300:        Loss=1.68,     Training Accuracy=46.0%
iter 400:        Loss=1.63,     Training Accuracy=46.0%
----------------------------------------------------------
Epoch: 49, validation loss: 1.78, validation accuracy: 39.8%
----------------------------------------------------------
Training epoch: 50
iter   0:        Loss=1.84,     Training Accuracy=37.0%
iter 100:        Loss=1.77,     Training Accuracy=34.0%
iter 200:        Loss=1.78,     Training Accuracy=45.0%
iter 300:        Loss=1.65,     Training Accuracy=48.0%
iter 400:        Loss=1.81,     Training Accuracy=36.0%
----------------------------------------------------------
Epoch: 50, validation loss: 1.79, validation accuracy: 41.4%
----------------------------------------------------------
```

In [24]:
```
y_train.shape[0]/100
```

Out[24]:
```
500.0
```

In [27]:
```
y_test[:1000].shape
```

Out[27]:
```
(1000, 10)
```

In [ ]:
```

```