578hw5

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CSC 578 (sect. 901) - Spring 2022
Assignment: HW 5

(0) Tiny experiment with One-training-One-test Iris data

[You can run the start-up code as is to generate this.]

In [1]:
```
import NN578_network2 as network2
import numpy as np

# Test with one-data Iris data

inst1 = (np.array([5.7, 3, 4.2, 1.2]), np.array([0., 1., 0.]))
x1 = np.reshape(inst1[0], (4, 1))
y1 = np.reshape(inst1[1], (3, 1))
sample1 = [(x1, y1)]
inst2 = (np.array([4.8, 3.4, 1.6, 0.2]), np.array([1., 0., 0.]))
x2 = np.reshape(inst2[0], (4, 1))
y2 = np.reshape(inst2[1], (3, 1))
sample2 = [(x2, y2)]

net4 = network2.load_network("iris-423.dat")
net4.set_parameters(cost=network2.QuadraticCost)

net4.SGD(sample1, 2, 1, 1.0, evaluation_data=sample2, monitor_evaluation_cost=True,
            monitor_evaluation_accuracy=True,
            monitor_training_cost=True,
            monitor_training_accuracy=True)
```

```
Epoch 0 training completed:
Cost on training data: 0.26673128660052947
Accuracy on training data: 1 / 1
Cost on evaluation data: 0.3244002758397572
Accuracy on evaluation data: 0 / 1

Epoch 1 training completed:
Cost on training data: 0.2107866577006649
Accuracy on training data: 1 / 1
Cost on evaluation data: 0.37647122809828165
Accuracy on evaluation data: 0 / 1
```

Out[1]:
```
([0.3244002758397572, 0.37647122809828165],
 [0, 0],
 [0.26673128660052947, 0.2107866577006649],
 [1, 1])
```

Load the iris_train, iris_test datasets

In [2]:
```
# Load the iris train-test (separate) data files
def my_load_csv(fname, no_trainfeatures, no_testfeatures):
    ret = np.genfromtxt(fname, delimiter=',')
    data = np.array([(entry[:no_trainfeatures],entry[no_trainfeatures:]) for entry in r
    temp_inputs = [np.reshape(x, (no_trainfeatures, 1)) for x in data[:,0]]
    temp_results = [np.reshape(y, (no_testfeatures, 1)) for y in data[:,1]]
    dataset = list(zip(temp_inputs, temp_results))
    return dataset

iris_train = my_load_csv('iris-train-1.csv', 4, 3)
iris_test = my_load_csv('iris-test-1.csv', 4, 3)
```

```
C:\Users\Home\AppData\Local\Temp/ipykernel_12848/1570339441.py:4: VisibleDeprecationWarn
ing: Creating an ndarray from ragged nested sequences (which is a list-or-tuple of lists
-or-tuples-or ndarrays with different lengths or shapes) is deprecated. If you meant to
do this, you must specify 'dtype=object' when creating the ndarray.
  data = np.array([(entry[:no_trainfeatures],entry[no_trainfeatures:]) for entry in re
t])
```

1.) Sigmoid + Sigmoid + QuadraticCost

[You can run the start-up code as is to generate this.]

In [3]:
```
net2 = network2.load_network("iris-423.dat")

# Set hyper-parameter values individually after the network
net2.set_parameters(cost=network2.QuadraticCost, act_hidden=network2.Sigmoid, act_outpu

net2.SGD(iris_train, 15, 10, 1.0, evaluation_data=iris_test, monitor_evaluation_cost=Tr
            monitor_evaluation_accuracy=True,
            monitor_training_cost=True,
            monitor_training_accuracy=True)
```

```
Epoch 0 training completed:
Cost on training data: 0.3392795030659105
Accuracy on training data: 21 / 95
Cost on evaluation data: 0.34444833747414394
Accuracy on evaluation data: 15 / 55

Epoch 1 training completed:
Cost on training data: 0.3332680387432046
Accuracy on training data: 33 / 95
Cost on evaluation data: 0.3357508215659017
Accuracy on evaluation data: 17 / 55

Epoch 2 training completed:
Cost on training data: 0.33169864345910943
Accuracy on training data: 33 / 95
Cost on evaluation data: 0.33331819877313307
Accuracy on evaluation data: 17 / 55

Epoch 3 training completed:
Cost on training data: 0.3280047701277544
Accuracy on training data: 33 / 95
Cost on evaluation data: 0.32931297694327877
Accuracy on evaluation data: 17 / 55
```

```
Epoch 4 training completed:
Cost on training data: 0.3105024143021552
Accuracy on training data: 65 / 95
Cost on evaluation data: 0.311452504680719
Accuracy on evaluation data: 35 / 55

Epoch 5 training completed:
Cost on training data: 0.2822226213778409
Accuracy on training data: 64 / 95
Cost on evaluation data: 0.28266644748693787
Accuracy on evaluation data: 39 / 55

Epoch 6 training completed:
Cost on training data: 0.26185308519985034
Accuracy on training data: 65 / 95
Cost on evaluation data: 0.2622221163236103
Accuracy on evaluation data: 40 / 55

Epoch 7 training completed:
Cost on training data: 0.24637620748622577
Accuracy on training data: 64 / 95
Cost on evaluation data: 0.24693122708939252
Accuracy on evaluation data: 40 / 55

Epoch 8 training completed:
Cost on training data: 0.23397287354343002
Accuracy on training data: 65 / 95
Cost on evaluation data: 0.23484243915532602
Accuracy on evaluation data: 41 / 55

Epoch 9 training completed:
Cost on training data: 0.2240389321795399
Accuracy on training data: 67 / 95
Cost on evaluation data: 0.22523745295521982
Accuracy on evaluation data: 41 / 55

Epoch 10 training completed:
Cost on training data: 0.21604989548512998
Accuracy on training data: 70 / 95
Cost on evaluation data: 0.2175515310927702
Accuracy on evaluation data: 44 / 55

Epoch 11 training completed:
Cost on training data: 0.20957620155325693
Accuracy on training data: 73 / 95
Cost on evaluation data: 0.21134700807259035
Accuracy on evaluation data: 47 / 55

Epoch 12 training completed:
Cost on training data: 0.2042808031846783
Accuracy on training data: 81 / 95
Cost on evaluation data: 0.20628846293823358
Accuracy on evaluation data: 52 / 55

Epoch 13 training completed:
Cost on training data: 0.19990418595499362
Accuracy on training data: 94 / 95
Cost on evaluation data: 0.2021204428263281
Accuracy on evaluation data: 54 / 55
```

```
Epoch 14 training completed:
Cost on training data: 0.1962475462149834
Accuracy on training data: 65 / 95
Cost on evaluation data: 0.19864854335473608
Accuracy on evaluation data: 35 / 55
```

Out[3]:

```
([0.34444833747414394,
  0.3357508215659017,
  0.33331819877313307,
  0.32931297694327877,
  0.311452504680719,
  0.28266644748693787,
  0.2622221163236103,
  0.24693122708939252,
  0.23484243915532602,
  0.22523745295521982,
  0.2175515310927702,
  0.21134700807259035,
  0.20628846293823358,
  0.2021204428263281,
  0.19864854335473608],
 [15, 17, 17, 17, 35, 39, 40, 40, 41, 41, 44, 47, 52, 54, 35],
 [0.3392795030659105,
  0.3332680387432046,
  0.33169864345910943,
  0.3280047701277544,
  0.3105024143021552,
  0.2822226213778409,
  0.26185308519985034,
  0.24637620748622577,
  0.23397287354343002,
  0.2240389321795399,
  0.21604989548512998,
  0.20957620155325693,
  0.2042808031846783,
  0.19990418595499362,
  0.1962475462149834],
 [21, 33, 33, 33, 65, 64, 65, 64, 65, 67, 70, 73, 81, 94, 65])
```

2.) Sigmoid + Sigmoid + CrossEntropy

In [4]:

```
net2 = network2.load_network("iris-423.dat")
net2.set_parameters(cost=network2.CrossEntropyCost, act_hidden=network2.Sigmoid, act_ou
net2.SGD(iris_train, 15, 10, 1.0, evaluation_data=iris_test, monitor_evaluation_cost=Tr
            monitor_evaluation_accuracy=True,
            monitor_training_cost=True,
            monitor_training_accuracy=True)
```

```
Epoch 0 training completed:
Cost on training data: 1.8603802674198153
Accuracy on training data: 33 / 95
Cost on evaluation data: 1.86801026041802
Accuracy on evaluation data: 18 / 55

Epoch 1 training completed:
Cost on training data: 1.460606534019205
Accuracy on training data: 69 / 95
Cost on evaluation data: 1.4660555356377223
```

```
Accuracy on evaluation data: 44 / 55

Epoch 2 training completed:
Cost on training data: 1.2667163241805766
Accuracy on training data: 92 / 95
Cost on evaluation data: 1.2774861545892018
Accuracy on evaluation data: 54 / 55

Epoch 3 training completed:
Cost on training data: 1.157146339882345
Accuracy on training data: 65 / 95
Cost on evaluation data: 1.1718471307186424
Accuracy on evaluation data: 35 / 55

Epoch 4 training completed:
Cost on training data: 1.0668798505712163
Accuracy on training data: 65 / 95
Cost on evaluation data: 1.086639159620854
Accuracy on evaluation data: 35 / 55

Epoch 5 training completed:
Cost on training data: 1.0269316288572257
Accuracy on training data: 65 / 95
Cost on evaluation data: 1.0468525231446604
Accuracy on evaluation data: 35 / 55

Epoch 6 training completed:
Cost on training data: 1.0030159043215205
Accuracy on training data: 65 / 95
Cost on evaluation data: 1.0230817418856184
Accuracy on evaluation data: 35 / 55

Epoch 7 training completed:
Cost on training data: 0.9876051818657172
Accuracy on training data: 65 / 95
Cost on evaluation data: 1.008345450466028
Accuracy on evaluation data: 35 / 55

Epoch 8 training completed:
Cost on training data: 0.9772276017636307
Accuracy on training data: 65 / 95
Cost on evaluation data: 0.999039774981281
Accuracy on evaluation data: 35 / 55

Epoch 9 training completed:
Cost on training data: 0.9690604086884841
Accuracy on training data: 65 / 95
Cost on evaluation data: 0.9916782036368461
Accuracy on evaluation data: 35 / 55

Epoch 10 training completed:
Cost on training data: 0.9623999454604479
Accuracy on training data: 64 / 95
Cost on evaluation data: 0.9856464279019425
Accuracy on evaluation data: 35 / 55

Epoch 11 training completed:
Cost on training data: 0.9564443218222219
Accuracy on training data: 64 / 95
Cost on evaluation data: 0.9800468983199269
```

```
Accuracy on evaluation data: 35 / 55

Epoch 12 training completed:
Cost on training data: 0.9519759891060913
Accuracy on training data: 64 / 95
Cost on evaluation data: 0.9761371328834577
Accuracy on evaluation data: 34 / 55

Epoch 13 training completed:
Cost on training data: 0.9459190082319816
Accuracy on training data: 64 / 95
Cost on evaluation data: 0.969683184172588
Accuracy on evaluation data: 35 / 55

Epoch 14 training completed:
Cost on training data: 0.9566747295347074
Accuracy on training data: 64 / 95
Cost on evaluation data: 0.9846220534440595
Accuracy on evaluation data: 34 / 55
```

Out[4]:

```
([1.86801026041802,
  1.4660555356377223,
  1.2774861545892018,
  1.1718471307186424,
  1.086639159620854,
  1.0468525231446604,
  1.0230817418856184,
  1.008345450466028,
  0.999039774981281,
  0.9916782036368461,
  0.9856464279019425,
  0.9800468983199269,
  0.9761371328834577,
  0.969683184172588,
  0.9846220534440595],
 [18, 44, 54, 35, 35, 35, 35, 35, 35, 35, 35, 35, 34, 35, 34],
 [1.8603802674198153,
  1.460606534019205,
  1.2667163241805766,
  1.157146339882345,
  1.0668798505712163,
  1.0269316288572257,
  1.0030159043215205,
  0.9876051818657172,
  0.9772276017636307,
  0.9690604086884841,
  0.9623999454604479,
  0.9564443218222219,
  0.9519759891060913,
  0.9459190082319816,
  0.9566747295347074],
 [33, 69, 92, 65, 65, 65, 65, 65, 65, 65, 64, 64, 64, 64, 64])
```

3.) Sigmoid + Softmax + CrossEntropy

In [5]:

```
net2 = network2.load_network("iris-423.dat")
net2.set_parameters(cost=network2.CrossEntropyCost, act_hidden=network2.Sigmoid, act_ou
net2.SGD(iris_train, 15, 10, 1.0, evaluation_data=iris_test, monitor_evaluation_cost=Tr
```

```
            monitor_evaluation_accuracy=True,
            monitor_training_cost=True,
            monitor_training_accuracy=True)
```

```
Epoch 0 training completed:
Cost on training data: 2.0796657352958428
Accuracy on training data: 33 / 95
Cost on evaluation data: 2.07795549824303
Accuracy on evaluation data: 17 / 55

Epoch 1 training completed:
Cost on training data: 2.1081016503185976
Accuracy on training data: 30 / 95
Cost on evaluation data: 2.084467814912433
Accuracy on evaluation data: 20 / 55

Epoch 2 training completed:
Cost on training data: 1.4541543371504533
Accuracy on training data: 65 / 95
Cost on evaluation data: 1.471013185139868
Accuracy on evaluation data: 35 / 55

Epoch 3 training completed:
Cost on training data: 1.3593731962677664
Accuracy on training data: 65 / 95
Cost on evaluation data: 1.3771843148926954
Accuracy on evaluation data: 35 / 55

Epoch 4 training completed:
Cost on training data: 1.2951970290596304
Accuracy on training data: 65 / 95
Cost on evaluation data: 1.312657405577991
Accuracy on evaluation data: 35 / 55

Epoch 5 training completed:
Cost on training data: 1.2681191220733508
Accuracy on training data: 65 / 95
Cost on evaluation data: 1.28409225197581
Accuracy on evaluation data: 35 / 55

Epoch 6 training completed:
Cost on training data: 1.2516090174753143
Accuracy on training data: 90 / 95
Cost on evaluation data: 1.2674210708592946
Accuracy on evaluation data: 54 / 55

Epoch 7 training completed:
Cost on training data: 1.2380695869912535
Accuracy on training data: 82 / 95
Cost on evaluation data: 1.2530388157445334
Accuracy on evaluation data: 53 / 55

Epoch 8 training completed:
Cost on training data: 1.9852822105249133
Accuracy on training data: 33 / 95
Cost on evaluation data: 1.986221001850633
Accuracy on evaluation data: 17 / 55

Epoch 9 training completed:
Cost on training data: 1.5469199772545184
```

```
Accuracy on training data: 65 / 95
Cost on evaluation data: 1.5700675916962603
Accuracy on evaluation data: 35 / 55

Epoch 10 training completed:
Cost on training data: 1.4192901931260125
Accuracy on training data: 65 / 95
Cost on evaluation data: 1.4369537506240186
Accuracy on evaluation data: 35 / 55

Epoch 11 training completed:
Cost on training data: 1.3627170578384147
Accuracy on training data: 65 / 95
Cost on evaluation data: 1.3786635371360327
Accuracy on evaluation data: 35 / 55

Epoch 12 training completed:
Cost on training data: 1.3301597588377747
Accuracy on training data: 65 / 95
Cost on evaluation data: 1.3454699199602322
Accuracy on evaluation data: 35 / 55

Epoch 13 training completed:
Cost on training data: 1.3088172090796717
Accuracy on training data: 65 / 95
Cost on evaluation data: 1.3238931293763883
Accuracy on evaluation data: 35 / 55

Epoch 14 training completed:
Cost on training data: 1.2936066661058043
Accuracy on training data: 65 / 95
Cost on evaluation data: 1.3085501395134322
Accuracy on evaluation data: 35 / 55
```

Out[5]:

```
([2.07795549824303,
  2.084467814912433,
  1.471013185139868,
  1.3771843148926954,
  1.312657405577991,
  1.28409225197581,
  1.2674210708592946,
  1.2530388157445334,
  1.986221001850633,
  1.5700675916962603,
  1.4369537506240186,
  1.3786635371360327,
  1.3454699199602322,
  1.3238931293763883,
  1.3085501395134322],
 [17, 20, 35, 35, 35, 35, 54, 53, 17, 35, 35, 35, 35, 35, 35],
 [2.0796657352958428,
  2.1081016503185976,
  1.4541543371504533,
  1.3593731962677664,
  1.295197029059630 4,
  1.2681191220733508,
  1.2516090174753143,
  1.2380695869912535,
  1.9852822105249133,
  1.5469199772545184,
```

```
  1.4192901931260125,
  1.3627170578384147,
  1.3301597588377747,
  1.3088172090796717,
  1.2936066661058043],
 [33, 30, 65, 65, 65, 65, 90, 82, 33, 65, 65, 65, 65, 65, 65])
```

4.) Sigmoid + Softmax + LogLikelihood

In [6]:

```
net2 = network2.load_network("iris-423.dat")
net2.set_parameters(cost=network2.LogLikelihood, act_hidden=network2.Sigmoid, act_outpu
net2.SGD(iris_train, 15, 10, 1.0, evaluation_data=iris_test, monitor_evaluation_cost=Tr
            monitor_evaluation_accuracy=True,
            monitor_training_cost=True,
            monitor_training_accuracy=True)
```

```
Epoch 0 training completed:
Cost on training data: 0.6939243673335762
Accuracy on training data: 33 / 95
Cost on evaluation data: 0.7031655365603354
Accuracy on evaluation data: 17 / 55

Epoch 1 training completed:
Cost on training data: 0.6730652668308285
Accuracy on training data: 65 / 95
Cost on evaluation data: 0.6777321600362607
Accuracy on evaluation data: 35 / 55

Epoch 2 training completed:
Cost on training data: 0.5367911920292118
Accuracy on training data: 62 / 95
Cost on evaluation data: 0.5379424339473955
Accuracy on evaluation data: 38 / 55

Epoch 3 training completed:
Cost on training data: 0.4514534117603832
Accuracy on training data: 76 / 95
Cost on evaluation data: 0.4548586660780302
Accuracy on evaluation data: 48 / 55

Epoch 4 training completed:
Cost on training data: 0.39804390388092464
Accuracy on training data: 65 / 95
Cost on evaluation data: 0.40323109144970604
Accuracy on evaluation data: 35 / 55

Epoch 5 training completed:
Cost on training data: 0.36183435942190195
Accuracy on training data: 65 / 95
Cost on evaluation data: 0.36806978016245706
Accuracy on evaluation data: 35 / 55

Epoch 6 training completed:
Cost on training data: 0.3354020988700623
Accuracy on training data: 65 / 95
Cost on evaluation data: 0.3422726187823812
Accuracy on evaluation data: 35 / 55
```

```
Epoch 7 training completed:
Cost on training data: 0.31450402496867513
Accuracy on training data: 65 / 95
Cost on evaluation data: 0.3218231140418876
Accuracy on evaluation data: 35 / 55

Epoch 8 training completed:
Cost on training data: 0.29527887251633794
Accuracy on training data: 65 / 95
Cost on evaluation data: 0.30305997493736614
Accuracy on evaluation data: 35 / 55

Epoch 9 training completed:
Cost on training data: 0.27647172570197487
Accuracy on training data: 65 / 95
Cost on evaluation data: 0.28470876038901277
Accuracy on evaluation data: 35 / 55

Epoch 10 training completed:
Cost on training data: 0.2627274252603041
Accuracy on training data: 65 / 95
Cost on evaluation data: 0.27132925460559537
Accuracy on evaluation data: 35 / 55

Epoch 11 training completed:
Cost on training data: 0.2559923749291393
Accuracy on training data: 65 / 95
Cost on evaluation data: 0.26490353136483763
Accuracy on evaluation data: 35 / 55

Epoch 12 training completed:
Cost on training data: 0.25766716116151905
Accuracy on training data: 65 / 95
Cost on evaluation data: 0.2661945900587034
Accuracy on evaluation data: 35 / 55

Epoch 13 training completed:
Cost on training data: 0.26090806873534517
Accuracy on training data: 64 / 95
Cost on evaluation data: 0.2678074258190117
Accuracy on evaluation data: 34 / 55

Epoch 14 training completed:
Cost on training data: 0.26672994719457715
Accuracy on training data: 64 / 95
Cost on evaluation data: 0.27060475155253877
Accuracy on evaluation data: 34 / 55
```

Out[6]:

```
([0.7031655365603354,
  0.6777321600362607,
  0.5379424339473955,
  0.4548586660780302,
  0.40323109144970604,
  0.36806978016245706,
  0.3422726187823812,
  0.3218231140418876,
  0.30305997493736614,
  0.28470876038901277,
  0.27132925460559537,
  0.26490353136483763,
```

```
 0.2661945900587034,
 0.2678074258190117,
 0.27060475155253877],
[17, 35, 38, 48, 35, 35, 35, 35, 35, 35, 35, 35, 35, 34, 34],
[0.6939243673335762,
 0.6730652668308285,
 0.5367911920292118,
 0.4514534117603832,
 0.39804390388092464,
 0.36183435942190195,
 0.3354020988700623,
 0.31450402496867513,
 0.29527887251633794,
 0.27647172570197487,
 0.2627274252603041,
 0.2559923749291393,
 0.25766716116151905,
 0.26090806873534517,
 0.26672994719457715],
[33, 65, 62, 76, 65, 65, 65, 65, 65, 65, 65, 65, 65, 64, 64])
```

5.) ReLU + Softmax + CrossEntropy

In [7]:

```
net2 = network2.load_network("iris-423.dat")
net2.set_parameters(cost=network2.CrossEntropyCost, act_hidden=network2.ReLU, act_outpu
net2.SGD(iris_train, 15, 10, 1.0, evaluation_data=iris_test, monitor_evaluation_cost=Tr
            monitor_evaluation_accuracy=True,
            monitor_training_cost=True,
            monitor_training_accuracy=True)
```

```
C:\Users\Home\NN578_network2.py:61: RuntimeWarning: invalid value encountered in true_di
vide
  return -( (a-y) / ((a-1) * a) )
C:\Users\Home\NN578_network2.py:61: RuntimeWarning: divide by zero encountered in true_d
ivide
  return -( (a-y) / ((a-1) * a) )
Epoch 0 training completed:
Cost on training data: nan
Accuracy on training data: 32 / 95
Cost on evaluation data: nan
Accuracy on evaluation data: 18 / 55

Epoch 1 training completed:
Cost on training data: nan
Accuracy on training data: 32 / 95
Cost on evaluation data: nan
Accuracy on evaluation data: 18 / 55

Epoch 2 training completed:
Cost on training data: nan
Accuracy on training data: 32 / 95
Cost on evaluation data: nan
Accuracy on evaluation data: 18 / 55

Epoch 3 training completed:
Cost on training data: nan
Accuracy on training data: 32 / 95
Cost on evaluation data: nan
```

```
Accuracy on evaluation data: 18 / 55

Epoch 4 training completed:
Cost on training data: nan
Accuracy on training data: 32 / 95
Cost on evaluation data: nan
Accuracy on evaluation data: 18 / 55

Epoch 5 training completed:
Cost on training data: nan
Accuracy on training data: 32 / 95
Cost on evaluation data: nan
Accuracy on evaluation data: 18 / 55

Epoch 6 training completed:
Cost on training data: nan
Accuracy on training data: 32 / 95
Cost on evaluation data: nan
Accuracy on evaluation data: 18 / 55

Epoch 7 training completed:
Cost on training data: nan
Accuracy on training data: 32 / 95
Cost on evaluation data: nan
Accuracy on evaluation data: 18 / 55

Epoch 8 training completed:
Cost on training data: nan
Accuracy on training data: 32 / 95
Cost on evaluation data: nan
Accuracy on evaluation data: 18 / 55

Epoch 9 training completed:
Cost on training data: nan
Accuracy on training data: 32 / 95
Cost on evaluation data: nan
Accuracy on evaluation data: 18 / 55

Epoch 10 training completed:
Cost on training data: nan
Accuracy on training data: 32 / 95
Cost on evaluation data: nan
Accuracy on evaluation data: 18 / 55

Epoch 11 training completed:
Cost on training data: nan
Accuracy on training data: 32 / 95
Cost on evaluation data: nan
Accuracy on evaluation data: 18 / 55

Epoch 12 training completed:
Cost on training data: nan
Accuracy on training data: 32 / 95
Cost on evaluation data: nan
Accuracy on evaluation data: 18 / 55

Epoch 13 training completed:
Cost on training data: nan
Accuracy on training data: 32 / 95
Cost on evaluation data: nan
```

```
Accuracy on evaluation data: 18 / 55

Epoch 14 training completed:
Cost on training data: nan
Accuracy on training data: 32 / 95
Cost on evaluation data: nan
Accuracy on evaluation data: 18 / 55
```

Out[7]:

```
([nan, nan, nan, nan, nan, nan, nan, nan, nan, nan, nan, nan, nan, nan, nan],
 [18, 18, 18, 18, 18, 18, 18, 18, 18, 18, 18, 18, 18, 18, 18],
 [nan, nan, nan, nan, nan, nan, nan, nan, nan, nan, nan, nan, nan, nan, nan],
 [32, 32, 32, 32, 32, 32, 32, 32, 32, 32, 32, 32, 32, 32, 32])
```

6.) ReLU + Softmax + LogLikelihood

In [8]:

```
net2 = network2.load_network("iris-423.dat")
net2.set_parameters(cost=network2.LogLikelihood, act_hidden=network2.ReLU, act_output=n
net2.SGD(iris_train, 15, 10, 1.0, evaluation_data=iris_test, monitor_evaluation_cost=Tr
            monitor_evaluation_accuracy=True,
            monitor_training_cost=True,
            monitor_training_accuracy=True)
```

```
C:\Users\Home\NN578_network2.py:75: RuntimeWarning: divide by zero encountered in true_d
ivide
  a[x] = y[x] * (-1 / a[x])
C:\Users\Home\NN578_network2.py:75: RuntimeWarning: invalid value encountered in multipl
y
  a[x] = y[x] * (-1 / a[x])
Epoch 0 training completed:
Cost on training data: nan
Accuracy on training data: 32 / 95
Cost on evaluation data: nan
Accuracy on evaluation data: 18 / 55

Epoch 1 training completed:
Cost on training data: nan
Accuracy on training data: 32 / 95
Cost on evaluation data: nan
Accuracy on evaluation data: 18 / 55

Epoch 2 training completed:
Cost on training data: nan
Accuracy on training data: 32 / 95
Cost on evaluation data: nan
Accuracy on evaluation data: 18 / 55

Epoch 3 training completed:
Cost on training data: nan
Accuracy on training data: 32 / 95
Cost on evaluation data: nan
Accuracy on evaluation data: 18 / 55

Epoch 4 training completed:
Cost on training data: nan
Accuracy on training data: 32 / 95
Cost on evaluation data: nan
Accuracy on evaluation data: 18 / 55
```

```
Epoch 5 training completed:
Cost on training data: nan
Accuracy on training data: 32 / 95
Cost on evaluation data: nan
Accuracy on evaluation data: 18 / 55

Epoch 6 training completed:
Cost on training data: nan
Accuracy on training data: 32 / 95
Cost on evaluation data: nan
Accuracy on evaluation data: 18 / 55

Epoch 7 training completed:
Cost on training data: nan
Accuracy on training data: 32 / 95
Cost on evaluation data: nan
Accuracy on evaluation data: 18 / 55

Epoch 8 training completed:
Cost on training data: nan
Accuracy on training data: 32 / 95
Cost on evaluation data: nan
Accuracy on evaluation data: 18 / 55

Epoch 9 training completed:
Cost on training data: nan
Accuracy on training data: 32 / 95
Cost on evaluation data: nan
Accuracy on evaluation data: 18 / 55

Epoch 10 training completed:
Cost on training data: nan
Accuracy on training data: 32 / 95
Cost on evaluation data: nan
Accuracy on evaluation data: 18 / 55

Epoch 11 training completed:
Cost on training data: nan
Accuracy on training data: 32 / 95
Cost on evaluation data: nan
Accuracy on evaluation data: 18 / 55

Epoch 12 training completed:
Cost on training data: nan
Accuracy on training data: 32 / 95
Cost on evaluation data: nan
Accuracy on evaluation data: 18 / 55

Epoch 13 training completed:
Cost on training data: nan
Accuracy on training data: 32 / 95
Cost on evaluation data: nan
Accuracy on evaluation data: 18 / 55

Epoch 14 training completed:
Cost on training data: nan
Accuracy on training data: 32 / 95
Cost on evaluation data: nan
Accuracy on evaluation data: 18 / 55
```

Out[8]:
```
([nan, nan, nan, nan, nan, nan, nan, nan, nan, nan, nan, nan, nan, nan, nan],
 [18, 18, 18, 18, 18, 18, 18, 18, 18, 18, 18, 18, 18, 18, 18],
 [nan, nan, nan, nan, nan, nan, nan, nan, nan, nan, nan, nan, nan, nan, nan],
 [32, 32, 32, 32, 32, 32, 32, 32, 32, 32, 32, 32, 32, 32, 32])
```

7.) Tanh + Sigmoid + Quadratic

In [ ]:
```
net2 = network2.load_network("iris-423.dat")
net2.set_parameters(cost=network2.QuadraticCost, act_hidden=network2.Tanh, act_output=n
net2.SGD(iris_train, 15, 10, 1.0, evaluation_data=iris_test, monitor_evaluation_cost=Tr
            monitor_evaluation_accuracy=True,
            monitor_training_cost=True,
            monitor_training_accuracy=True)
```

8.) Tanh + Tanh + Quadratic

In [9]:
```
net2 = network2.load_network("iris-423.dat")
net2.set_parameters(cost=network2.QuadraticCost, act_hidden=network2.Tanh, act_output=n
net2.SGD(iris_train, 15, 10, 1.0, evaluation_data=iris_test, monitor_evaluation_cost=Tr
            monitor_evaluation_accuracy=True,
            monitor_training_cost=True,
            monitor_training_accuracy=True)
```

```
Epoch 0 training completed:
Cost on training data: 1.5632335301768185
Accuracy on training data: 33 / 95
Cost on evaluation data: 1.6447817575121952
Accuracy on evaluation data: 17 / 55

Epoch 1 training completed:
Cost on training data: 1.7700632291149812
Accuracy on training data: 33 / 95
Cost on evaluation data: 1.8449848877025194
Accuracy on evaluation data: 17 / 55

Epoch 2 training completed:
Cost on training data: 1.5001812828599652
Accuracy on training data: 33 / 95
Cost on evaluation data: 1.535184506261475
Accuracy on evaluation data: 17 / 55

Epoch 3 training completed:
Cost on training data: 1.5570778586672658
Accuracy on training data: 33 / 95
Cost on evaluation data: 1.5640765577972784
Accuracy on evaluation data: 17 / 55

Epoch 4 training completed:
Cost on training data: 1.4008025520994258
Accuracy on training data: 33 / 95
Cost on evaluation data: 1.4146963617569082
Accuracy on evaluation data: 17 / 55

Epoch 5 training completed:
Cost on training data: 1.7515323813261168
Accuracy on training data: 33 / 95
```

```
Cost on evaluation data: 1.822561918834206
Accuracy on evaluation data: 17 / 55

Epoch 6 training completed:
Cost on training data: 1.6150277995757572
Accuracy on training data: 30 / 95
Cost on evaluation data: 1.562815581775495
Accuracy on evaluation data: 20 / 55

Epoch 7 training completed:
Cost on training data: 1.6128596745896908
Accuracy on training data: 33 / 95
Cost on evaluation data: 1.6450335179710491
Accuracy on evaluation data: 17 / 55

Epoch 8 training completed:
Cost on training data: 1.5134550423863589
Accuracy on training data: 33 / 95
Cost on evaluation data: 1.572842449392096
Accuracy on evaluation data: 17 / 55

Epoch 9 training completed:
Cost on training data: 1.7513250664487554
Accuracy on training data: 33 / 95
Cost on evaluation data: 1.8214008099324173
Accuracy on evaluation data: 17 / 55

Epoch 10 training completed:
Cost on training data: 1.449075407934458
Accuracy on training data: 33 / 95
Cost on evaluation data: 1.4702884872086581
Accuracy on evaluation data: 17 / 55

Epoch 11 training completed:
Cost on training data: 1.5583619128024333
Accuracy on training data: 33 / 95
Cost on evaluation data: 1.565074829644671
Accuracy on evaluation data: 17 / 55

Epoch 12 training completed:
Cost on training data: 1.457975318609516
Accuracy on training data: 33 / 95
Cost on evaluation data: 1.5021151270177782
Accuracy on evaluation data: 17 / 55

Epoch 13 training completed:
Cost on training data: 1.5744342087312004
Accuracy on training data: 33 / 95
Cost on evaluation data: 1.590566592898297
Accuracy on evaluation data: 17 / 55

Epoch 14 training completed:
Cost on training data: 1.4493504814476035
Accuracy on training data: 33 / 95
Cost on evaluation data: 1.464352906434339
Accuracy on evaluation data: 17 / 55
```

Out[9]:

```
([1.6447817575121952,
  1.8449848877025194,
  1.535184506261475,
```

```
 1.5640765577972784,
 1.4146963617569082,
 1.822561918834206,
 1.562815581775495,
 1.6450335179710491,
 1.572842449392096,
 1.8214008099324173,
 1.4702884872086581,
 1.565074829644671,
 1.5021151270177782,
 1.590566592898297,
 1.464352906434339],
[17, 17, 17, 17, 17, 17, 20, 17, 17, 17, 17, 17, 17, 17, 17],
[1.5632335301768185,
 1.7700632291149812,
 1.5001812828599652,
 1.5570778586672658,
 1.4008025520994258,
 1.7515323813261168,
 1.6150277995757572,
 1.6128596745896908,
 1.5134550423863589,
 1.7513250664487554,
 1.449075407934458,
 1.5583619128024333,
 1.457975318609516,
 1.5744342087312004,
 1.4493504814476035],
[33, 33, 33, 33, 33, 33, 30, 33, 33, 33, 33, 33, 33, 33, 33])
```

9.) Sigmoid + Sigmoid + Quadratic + L2 regularization + lmdba = 3.0

In [10]:

```
net2 = network2.load_network("iris-423.dat")
net2.set_parameters(cost=network2.QuadraticCost, act_hidden=network2.Sigmoid, act_outpu
                    regularization= 'L2', lmbda = 3.0)
net2.SGD(iris_train, 15, 10, 1.0, 3.0, evaluation_data=iris_test, monitor_evaluation_co
            monitor_evaluation_accuracy=True,
            monitor_training_cost=True,
            monitor_training_accuracy=True)
```

```
Epoch 0 training completed:
Cost on training data: 0.45886398333113254
Accuracy on training data: 30 / 95
Cost on evaluation data: 0.5509298016398527
Accuracy on evaluation data: 18 / 55

Epoch 1 training completed:
Cost on training data: 0.396623357612462
Accuracy on training data: 31 / 95
Cost on evaluation data: 0.4441627862193589
Accuracy on evaluation data: 20 / 55

Epoch 2 training completed:
Cost on training data: 0.35964315066025077
Accuracy on training data: 62 / 95
Cost on evaluation data: 0.38666765720485874
Accuracy on evaluation data: 38 / 55
```

```
Epoch 3 training completed:
Cost on training data: 0.34262845791173324
Accuracy on training data: 62 / 95
Cost on evaluation data: 0.36158436118873444
Accuracy on evaluation data: 38 / 55

Epoch 4 training completed:
Cost on training data: 0.33416123022543753
Accuracy on training data: 62 / 95
Cost on evaluation data: 0.35010483170635776
Accuracy on evaluation data: 38 / 55

Epoch 5 training completed:
Cost on training data: 0.3294987724480264
Accuracy on training data: 62 / 95
Cost on evaluation data: 0.34509465468848194
Accuracy on evaluation data: 38 / 55

Epoch 6 training completed:
Cost on training data: 0.3266100283714264
Accuracy on training data: 62 / 95
Cost on evaluation data: 0.3430922517975508
Accuracy on evaluation data: 38 / 55

Epoch 7 training completed:
Cost on training data: 0.3246207815335592
Accuracy on training data: 62 / 95
Cost on evaluation data: 0.34246860387826106
Accuracy on evaluation data: 38 / 55

Epoch 8 training completed:
Cost on training data: 0.32317949516790373
Accuracy on training data: 62 / 95
Cost on evaluation data: 0.3425544533429334
Accuracy on evaluation data: 38 / 55

Epoch 9 training completed:
Cost on training data: 0.3221101647238849
Accuracy on training data: 62 / 95
Cost on evaluation data: 0.3430183499957253
Accuracy on evaluation data: 38 / 55

Epoch 10 training completed:
Cost on training data: 0.3213076417081684
Accuracy on training data: 62 / 95
Cost on evaluation data: 0.34366623702130267
Accuracy on evaluation data: 39 / 55

Epoch 11 training completed:
Cost on training data: 0.3207007860256327
Accuracy on training data: 63 / 95
Cost on evaluation data: 0.3443769166605408
Accuracy on evaluation data: 39 / 55

Epoch 12 training completed:
Cost on training data: 0.32023794744722905
Accuracy on training data: 66 / 95
Cost on evaluation data: 0.3450754538270465
Accuracy on evaluation data: 42 / 55
```

```
Epoch 13 training completed:
Cost on training data: 0.3198807020878355
Accuracy on training data: 71 / 95
Cost on evaluation data: 0.3457187003821495
Accuracy on evaluation data: 44 / 55

Epoch 14 training completed:
Cost on training data: 0.3196005230464391
Accuracy on training data: 74 / 95
Cost on evaluation data: 0.34628541820429487
Accuracy on evaluation data: 47 / 55
```

Out[10]:

```
([0.5509298016398527,
  0.4441627862193589,
  0.38666765720485874,
  0.36158436118873444,
  0.35010483170635776,
  0.34509465468848194,
  0.3430922517975508,
  0.34246860387826106,
  0.3425544533429334,
  0.3430183499957253,
  0.34366623702130267,
  0.3443769166605408,
  0.3450754538270465,
  0.3457187003821495,
  0.34628541820429487],
 [18, 20, 38, 38, 38, 38, 38, 38, 38, 38, 39, 39, 42, 44, 47],
 [0.45886398333113254,
  0.396623357612462,
  0.35964315066025077,
  0.34262845791173324,
  0.33416123022543753,
  0.3294987724480264,
  0.3266100283714264,
  0.3246207815335592,
  0.32317949516790373,
  0.3221101647238849,
  0.3213076417081684,
  0.3207007860256327,
  0.32023794744722905,
  0.3198807020878355,
  0.3196005230464391],
 [30, 31, 62, 62, 62, 62, 62, 62, 62, 62, 62, 63, 66, 71, 74])
```

10.) Sigmoid + Sigmoid + Quadratic + L1 regularization + lmdba = 3.0

In [11]:

```
net2 = network2.load_network("iris-423.dat")
net2.set_parameters(cost=network2.QuadraticCost, act_hidden=network2.Sigmoid, act_outpu
                    regularization= 'L1', lmbda = 3.0)
net2.SGD(iris_train, 15, 10, 1.0, 3.0, evaluation_data=iris_test, monitor_evaluation_co
            monitor_evaluation_accuracy=True,
            monitor_training_cost=True,
            monitor_training_accuracy=True)
```

```
Epoch 0 training completed:
```

```
Cost on training data: inf
Accuracy on training data: 32 / 95
Cost on evaluation data: inf
Accuracy on evaluation data: 18 / 55

Epoch 1 training completed:
Cost on training data: nan
Accuracy on training data: 32 / 95
Cost on evaluation data: nan
Accuracy on evaluation data: 18 / 55

Epoch 2 training completed:
Cost on training data: nan
Accuracy on training data: 32 / 95
Cost on evaluation data: nan
Accuracy on evaluation data: 18 / 55

Epoch 3 training completed:
Cost on training data: nan
Accuracy on training data: 32 / 95
Cost on evaluation data: nan
Accuracy on evaluation data: 18 / 55

Epoch 4 training completed:
Cost on training data: nan
Accuracy on training data: 32 / 95
Cost on evaluation data: nan
Accuracy on evaluation data: 18 / 55

Epoch 5 training completed:
Cost on training data: nan
Accuracy on training data: 32 / 95
Cost on evaluation data: nan
Accuracy on evaluation data: 18 / 55

Epoch 6 training completed:
Cost on training data: nan
Accuracy on training data: 32 / 95
Cost on evaluation data: nan
Accuracy on evaluation data: 18 / 55

Epoch 7 training completed:
Cost on training data: nan
Accuracy on training data: 32 / 95
Cost on evaluation data: nan
Accuracy on evaluation data: 18 / 55

Epoch 8 training completed:
Cost on training data: nan
Accuracy on training data: 32 / 95
Cost on evaluation data: nan
Accuracy on evaluation data: 18 / 55

Epoch 9 training completed:
Cost on training data: nan
Accuracy on training data: 32 / 95
Cost on evaluation data: nan
Accuracy on evaluation data: 18 / 55

Epoch 10 training completed:
```

```
Cost on training data: nan
Accuracy on training data: 32 / 95
Cost on evaluation data: nan
Accuracy on evaluation data: 18 / 55

Epoch 11 training completed:
Cost on training data: nan
Accuracy on training data: 32 / 95
Cost on evaluation data: nan
Accuracy on evaluation data: 18 / 55

Epoch 12 training completed:
Cost on training data: nan
Accuracy on training data: 32 / 95
Cost on evaluation data: nan
Accuracy on evaluation data: 18 / 55

Epoch 13 training completed:
Cost on training data: nan
Accuracy on training data: 32 / 95
Cost on evaluation data: nan
Accuracy on evaluation data: 18 / 55

Epoch 14 training completed:
Cost on training data: nan
Accuracy on training data: 32 / 95
Cost on evaluation data: nan
Accuracy on evaluation data: 18 / 55

C:\Users\Home\NN578_network2.py:365: RuntimeWarning: overflow encountered in multiply
  self.weights = [(w - eta*(lmbda/n))*w-(eta/len(mini_batch))*nw
```

Out[11]:

```
([inf, nan, nan, nan, nan, nan, nan, nan, nan, nan, nan, nan, nan, nan, nan],
 [18, 18, 18, 18, 18, 18, 18, 18, 18, 18, 18, 18, 18, 18, 18],
 [inf, nan, nan, nan, nan, nan, nan, nan, nan, nan, nan, nan, nan, nan, nan],
 [32, 32, 32, 32, 32, 32, 32, 32, 32, 32, 32, 32, 32, 32, 32])
```

11.) Sigmoid + Sigmoid + Quadratic + dropout = 0.1

In [12]:

```
net2 = network2.load_network("iris4-20-7-3.dat")
net2.set_parameters(cost=network2.QuadraticCost, act_hidden=network2.Sigmoid, act_outpu
                    dropoutpercent = 0.1)
net2.SGD(iris_train, 15, 10, 1.0, evaluation_data=iris_test, monitor_evaluation_cost=Tr
            monitor_evaluation_accuracy=True,
            monitor_training_cost=True,
            monitor_training_accuracy=True)
```

```
Epoch 0 training completed:
Cost on training data: 0.3336667955156058
Accuracy on training data: 33 / 95
Cost on evaluation data: 0.3340502318609861
Accuracy on evaluation data: 17 / 55

Epoch 1 training completed:
Cost on training data: 0.3332282953779683
Accuracy on training data: 33 / 95
Cost on evaluation data: 0.3341661334651754
Accuracy on evaluation data: 17 / 55
```

```
Epoch 2 training completed:
Cost on training data: 0.3330813506592155
Accuracy on training data: 33 / 95
Cost on evaluation data: 0.3341394037726516
Accuracy on evaluation data: 17 / 55

Epoch 3 training completed:
Cost on training data: 0.33293080948950937
Accuracy on training data: 33 / 95
Cost on evaluation data: 0.334009078378 59
Accuracy on evaluation data: 17 / 55

Epoch 4 training completed:
Cost on training data: 0.3327648217001155
Accuracy on training data: 33 / 95
Cost on evaluation data: 0.3338341628370756
Accuracy on evaluation data: 17 / 55

Epoch 5 training completed:
Cost on training data: 0.332576419330871
Accuracy on training data: 33 / 95
Cost on evaluation data: 0.33362469576413845
Accuracy on evaluation data: 17 / 55

Epoch 6 training completed:
Cost on training data: 0.3323543612059436
Accuracy on training data: 33 / 95
Cost on evaluation data: 0.3333727906502334
Accuracy on evaluation data: 17 / 55

Epoch 7 training completed:
Cost on training data: 0.3320818502294503
Accuracy on training data: 33 / 95
Cost on evaluation data: 0.3330608493737543
Accuracy on evaluation data: 17 / 55

Epoch 8 training completed:
Cost on training data: 0.3317337158446753
Accuracy on training data: 33 / 95
Cost on evaluation data: 0.33266104171364164
Accuracy on evaluation data: 17 / 55

Epoch 9 training completed:
Cost on training data: 0.3312720769484439
Accuracy on training data: 33 / 95
Cost on evaluation data: 0.33213151921411743
Accuracy on evaluation data: 17 / 55

Epoch 10 training completed:
Cost on training data: 0.33064165296760584
Accuracy on training data: 33 / 95
Cost on evaluation data: 0.3314122377827083
Accuracy on evaluation data: 17 / 55

Epoch 11 training completed:
Cost on training data: 0.32976813842092795
Accuracy on training data: 33 / 95
Cost on evaluation data: 0.33042473815691026
Accuracy on evaluation data: 17 / 55
```

```
Epoch 12 training completed:
Cost on training data: 0.3285620500881858
Accuracy on training data: 33 / 95
Cost on evaluation data: 0.3290784066606187
Accuracy on evaluation data: 17 / 55

Epoch 13 training completed:
Cost on training data: 0.32691864943215937
Accuracy on training data: 33 / 95
Cost on evaluation data: 0.32727188136489754
Accuracy on evaluation data: 17 / 55

Epoch 14 training completed:
Cost on training data: 0.3246967924196013
Accuracy on training data: 33 / 95
Cost on evaluation data: 0.32486900864009394
Accuracy on evaluation data: 17 / 55
```

Out[12]:

```
([0.3340502318609861,
  0.3341661334651754,
  0.3341394037726516,
  0.33400907837859,
  0.3338341628370756,
  0.33362469576413845,
  0.3333727906502334,
  0.3330608493737543,
  0.33266104171364164,
  0.33213151921411743,
  0.3314122377827083,
  0.33042473815691026,
  0.3290784066606187,
  0.32727188136489754,
  0.32486900864009394],
 [17, 17, 17, 17, 17, 17, 17, 17, 17, 17, 17, 17, 17, 17, 17],
 [0.3336667955156058,
  0.3332282953779683,
  0.3330813506592155,
  0.33293080948950937,
  0.3327648217001155,
  0.332576419330871,
  0.3323543612059436,
  0.3320818502294503,
  0.3317337158446753,
  0.3312720769484439,
  0.33064165296760584,
  0.32976813842092795,
  0.3285620500881858,
  0.32691864943215937,
  0.3246967924196013],
 [33, 33, 33, 33, 33, 33, 33, 33, 33, 33, 33, 33, 33, 33, 33])
```

12.) Sigmoid + Sigmoid + Quadratic + dropout = 0.5

In [13]:

```
net2 = network2.load_network("iris4-20-7-3.dat")
net2.set_parameters(cost=network2.QuadraticCost, act_hidden=network2.Sigmoid, act_outpu
                    dropoutpercent = 0.5)
net2.SGD(iris_train, 15, 10, 1.0, evaluation_data=iris_test, monitor_evaluation_cost=Tr
            monitor_evaluation_accuracy=True,
```

```
            monitor_training_cost=True,
            monitor_training_accuracy=True)
```

```
Epoch 0 training completed:
Cost on training data: 0.3336667955156058
Accuracy on training data: 33 / 95
Cost on evaluation data: 0.3340502318609861
Accuracy on evaluation data: 17 / 55

Epoch 1 training completed:
Cost on training data: 0.3332282953779683
Accuracy on training data: 33 / 95
Cost on evaluation data: 0.3341661334651754
Accuracy on evaluation data: 17 / 55

Epoch 2 training completed:
Cost on training data: 0.3330813506592155
Accuracy on training data: 33 / 95
Cost on evaluation data: 0.3341394037726516
Accuracy on evaluation data: 17 / 55

Epoch 3 training completed:
Cost on training data: 0.33293080948950937
Accuracy on training data: 33 / 95
Cost on evaluation data: 0.33400907837859
Accuracy on evaluation data: 17 / 55

Epoch 4 training completed:
Cost on training data: 0.3327648217001155
Accuracy on training data: 33 / 95
Cost on evaluation data: 0.3338341628370756
Accuracy on evaluation data: 17 / 55

Epoch 5 training completed:
Cost on training data: 0.332576419330871
Accuracy on training data: 33 / 95
Cost on evaluation data: 0.33362469576413845
Accuracy on evaluation data: 17 / 55

Epoch 6 training completed:
Cost on training data: 0.3323543612059436
Accuracy on training data: 33 / 95
Cost on evaluation data: 0.3333727906502334
Accuracy on evaluation data: 17 / 55

Epoch 7 training completed:
Cost on training data: 0.3320818502294503
Accuracy on training data: 33 / 95
Cost on evaluation data: 0.3330608493737543
Accuracy on evaluation data: 17 / 55

Epoch 8 training completed:
Cost on training data: 0.3317337158446753
Accuracy on training data: 33 / 95
Cost on evaluation data: 0.33266104171364164
Accuracy on evaluation data: 17 / 55

Epoch 9 training completed:
Cost on training data: 0.3312720769484439
Accuracy on training data: 33 / 95
```

```
Cost on evaluation data: 0.33213151921411743
Accuracy on evaluation data: 17 / 55

Epoch 10 training completed:
Cost on training data: 0.33064165296760584
Accuracy on training data: 33 / 95
Cost on evaluation data: 0.3314122377827083
Accuracy on evaluation data: 17 / 55

Epoch 11 training completed:
Cost on training data: 0.32976813842092795
Accuracy on training data: 33 / 95
Cost on evaluation data: 0.33042473815691026
Accuracy on evaluation data: 17 / 55

Epoch 12 training completed:
Cost on training data: 0.3285620500881858
Accuracy on training data: 33 / 95
Cost on evaluation data: 0.3290784066606187
Accuracy on evaluation data: 17 / 55

Epoch 13 training completed:
Cost on training data: 0.32691864943215937
Accuracy on training data: 33 / 95
Cost on evaluation data: 0.32727188136489754
Accuracy on evaluation data: 17 / 55

Epoch 14 training completed:
Cost on training data: 0.3246967924196013
Accuracy on training data: 33 / 95
Cost on evaluation data: 0.32486900864009394
Accuracy on evaluation data: 17 / 55
```

Out[13]:

```
([0.3340502318609861,
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  0.3333727906502334,
  0.3330608493737543,
  0.33266104171364164,
  0.33213151921411743,
  0.3314122377827083,
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  0.32486900864009394],
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  0.3332282953779683,
  0.3330813506592155,
  0.33293080948950937,
  0.3327648217001155,
  0.332576419330871,
  0.3323543612059436,
  0.3320818502294503,
  0.3317337158446753,
  0.3312720769484439,
  0.33064165296760584,
```

```
 0.32976813842092795,
 0.3285620500881858,
 0.32691864943215937,
 0.3246967924196013],
[33, 33, 33, 33, 33, 33, 33, 33, 33, 33, 33, 33, 33, 33, 33])
```

In [ ]:

In [ ]: