Project Report: Neural Network from Scratch

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Project Report: Neural Network from Scratch

This software was developed for the course Practical Deep Learning, BGU, January 2020. The code is available on GitHub.

In this project we integrated the different parts of the Articial Neural Network framework which have been discussed in the course.

We present the results of the gradient tests and the accuracy plots for various learning-rates/mb sizes.

Preliminaries

First, go ahead and clone the repository:

```
$ git clone https://github.com/noamsgl/PDL201_HW1
```

Project Structure

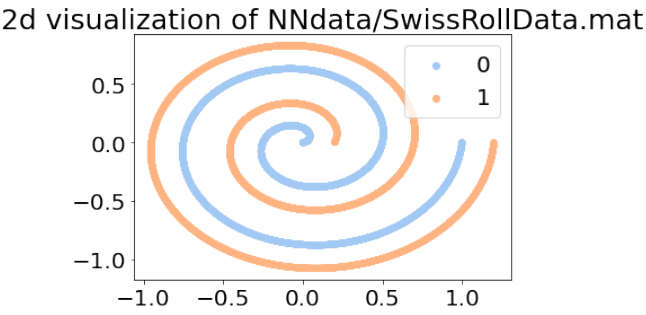
Structure your project as shown:

```
project_name
 NNdata
    GMMData.mat
    PeaksData.mat
    SwissRollData.mat
 utils.py
 tests.py
 parts123.py
 network.py
 Report.ipynb
```

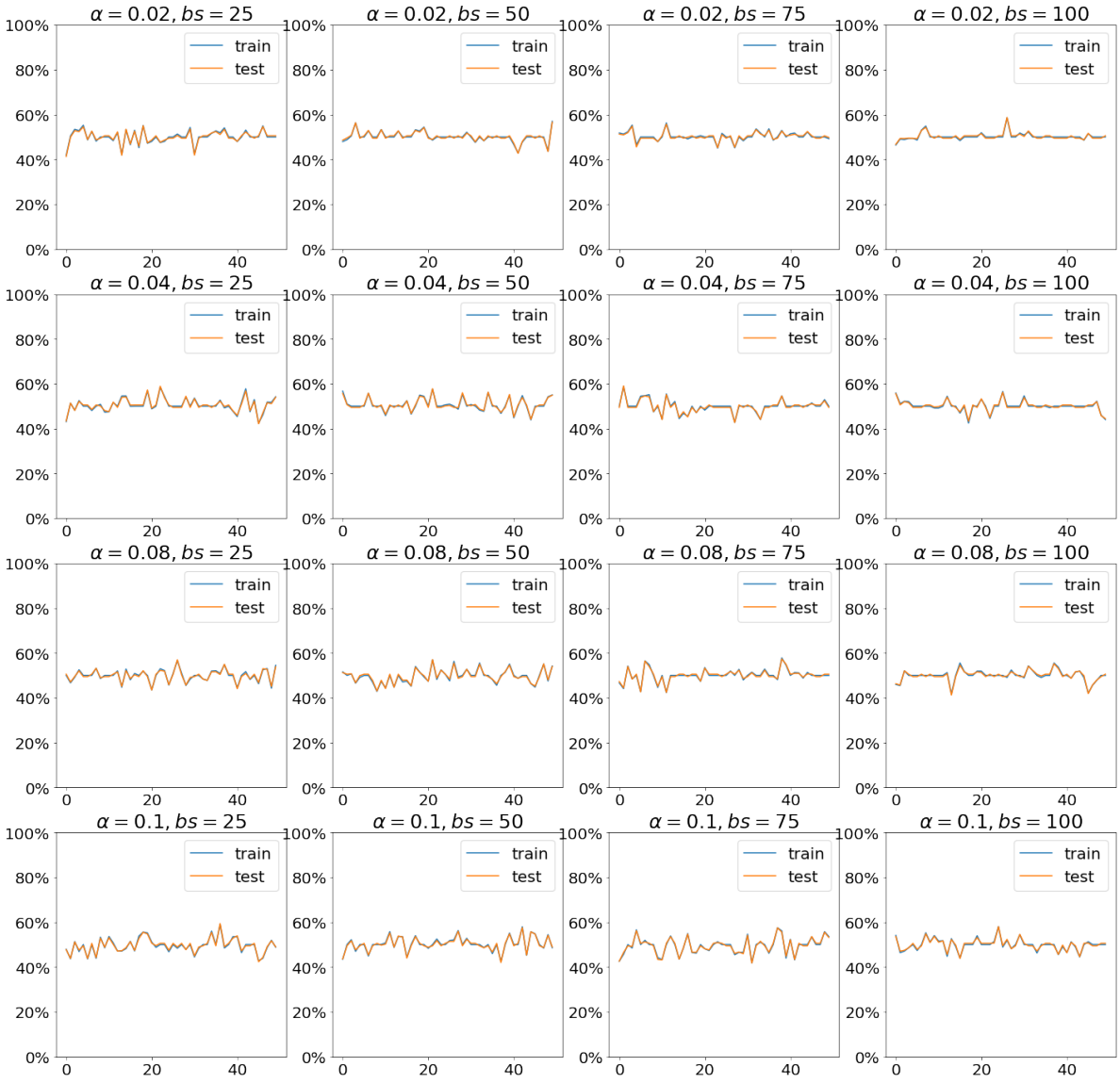
Tasks 1-3

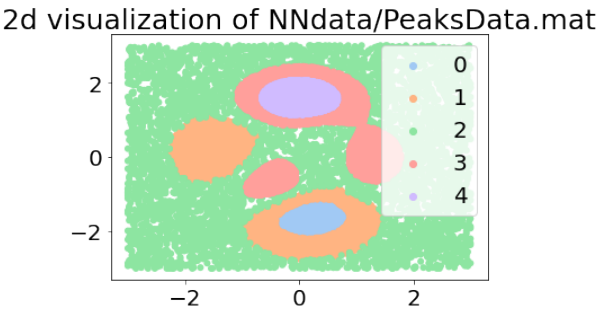
Execute SGD: zero hidden layers

[9]:
```
from parts123 import run_part_3
run_part_3(learning_rates=(0.02, 0.04, 0.08, 0.1),
           batch_sizes=(25, 50, 75, 100),
           iters=50)
```

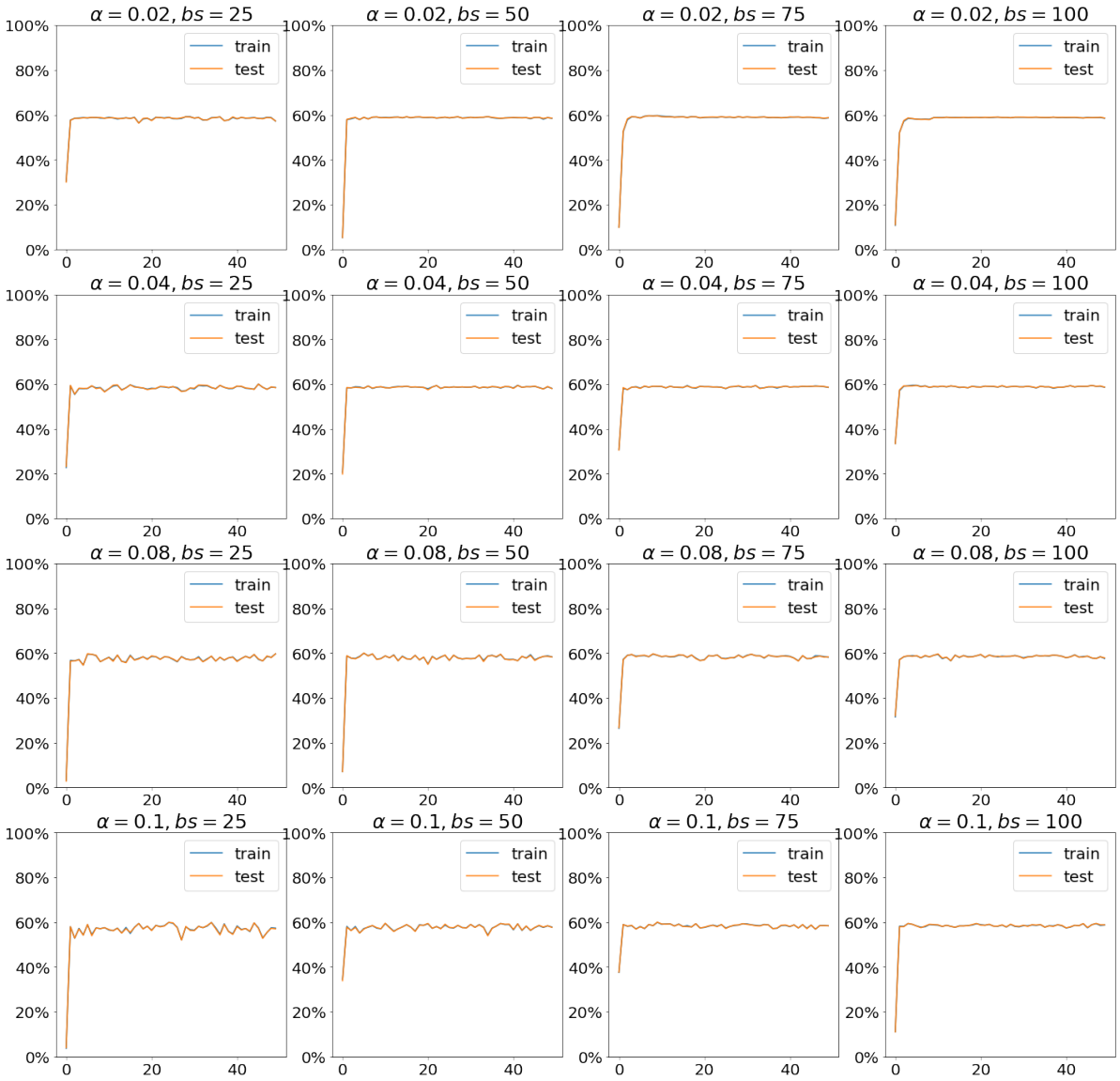


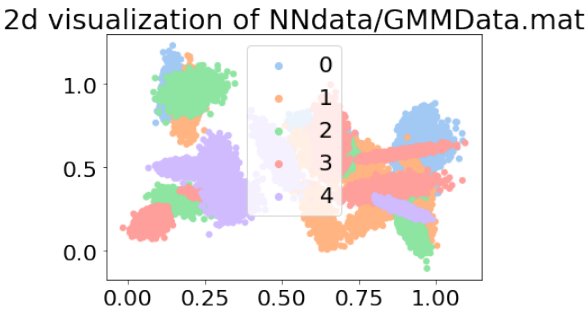
Accuracy vs. Epoch
Dataset: NNdata/SwissRollData.mat, Network Layers: []

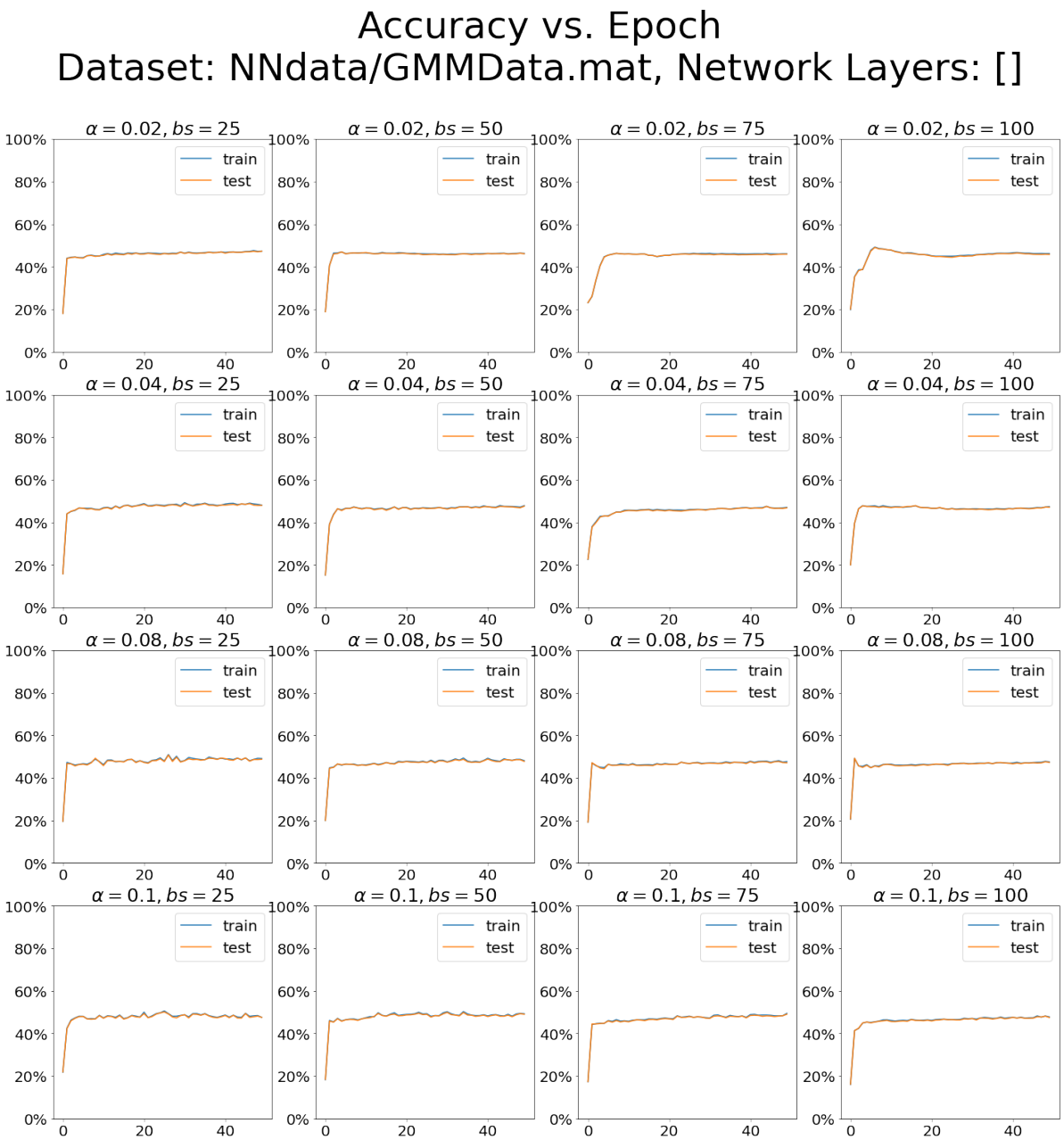




Accuracy vs. Epoch
Dataset: NNdata/PeaksData.mat, Network Layers: []




2d visualization of NNdata/GMMData.mat
0
1
2
3
4
1.0
0.5
0.0
0.00
0.25
0.50
0.75
1.00


Accuracy vs. Epoch
Dataset: NNdata/GMMData.mat, Network Layers: []
α = 0.02, bs = 25
α = 0.02, bs = 50
α = 0.02, bs = 75
α = 0.02, bs = 100
α = 0.04, bs = 25
α = 0.04, bs = 50
α = 0.04, bs = 75
α = 0.04, bs = 100
α = 0.08, bs = 25
α = 0.08, bs = 50
α = 0.08, bs = 75
α = 0.08, bs = 100
α = 0.1, bs = 25
α = 0.1, bs = 50
α = 0.1, bs = 75
α = 0.1, bs = 100
train
test
100%
80%
60%
40%
20%
0%
0
20
40

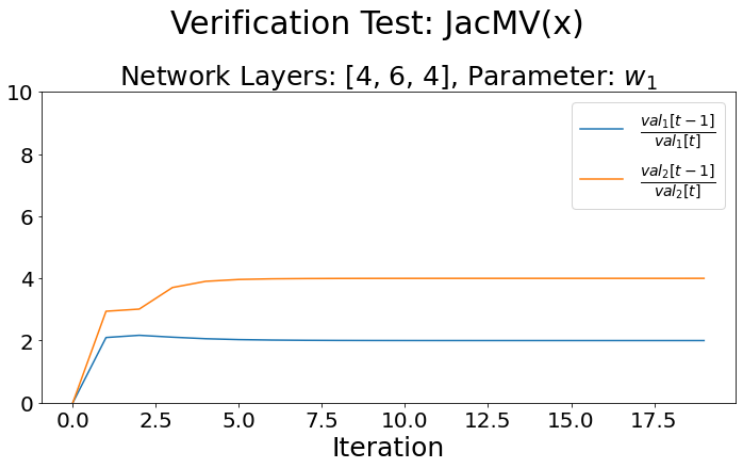
Task 4

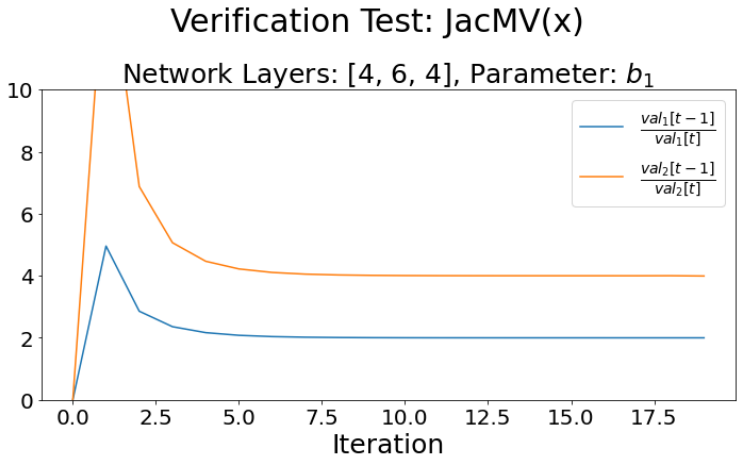
Jacobian Tests: one hidden layer

We perform the Jacobian test on $\frac{\partial F^T}{\partial w_1}\epsilon d$, $\frac{\partial F^T}{\partial b_l}\epsilon d$ for $l = 1$.

We denote: $val_1 := |f(x + \epsilon_i d) - f(x)|$, $val_2 := |f(x + \epsilon d) - f(x) - \epsilon d^T \texttt{JacMV}(x)|$

[10]:
```
from tests import gradient_test_for_hidden_layer_jacobian
input_dim = 4
output_dim = 4
hidden_layers_for_tests = [6]
gradient_test_for_hidden_layer_jacobian(input_dim, output_dim, samples=1,␣
 ↪hidden_layers_sizes=hidden_layers_for_tests,
                                        iters=20, optimizer='None')
```

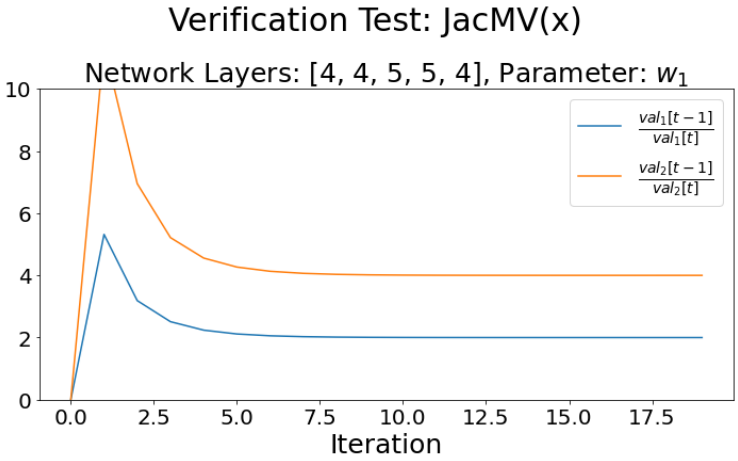


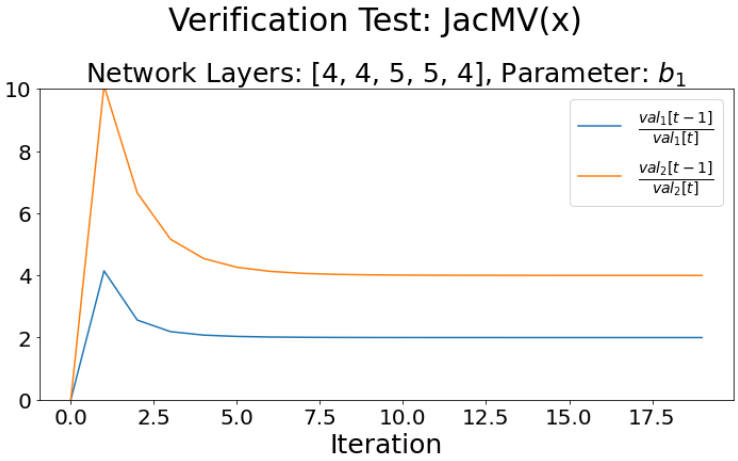


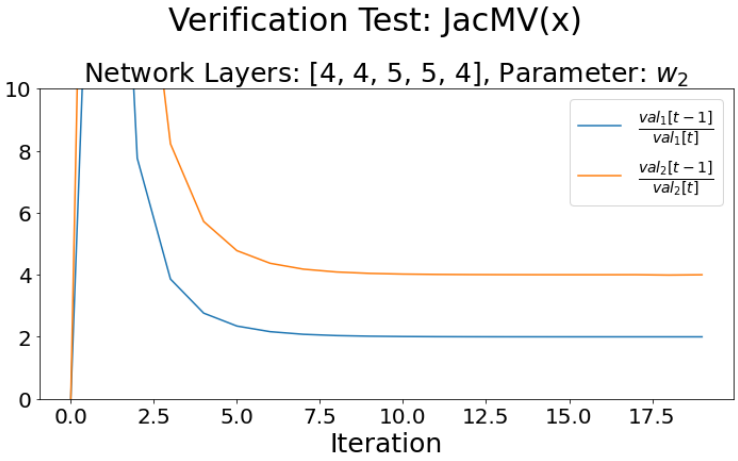
Jacboian Tests: several hidden layers

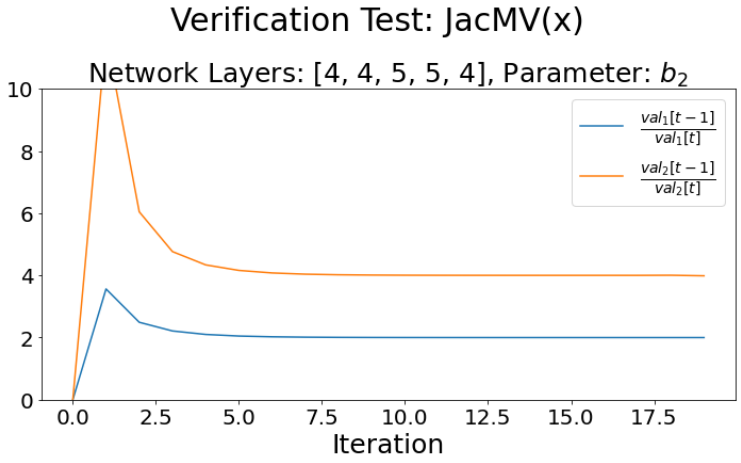
We perform the Jacobian test on $\frac{\partial F^T}{\partial w_l}\epsilon d$, $\frac{\partial F^T}{\partial b_l}\epsilon d$ for all layers $l \in \{1, ..., L\}$.

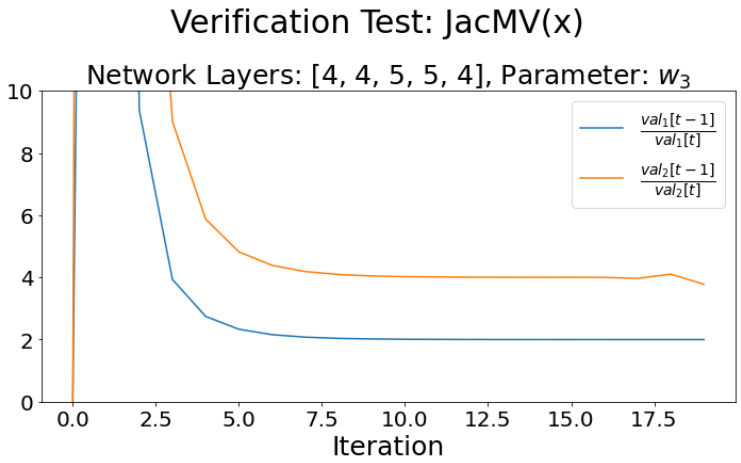
[11]:
```
hidden_layers_for_tests = [4, 5, 5]
gradient_test_for_hidden_layer_jacobian(input_dim, output_dim, samples=1,␣
 ↪hidden_layers_sizes=hidden_layers_for_tests, iters=20, optimizer='None')
```

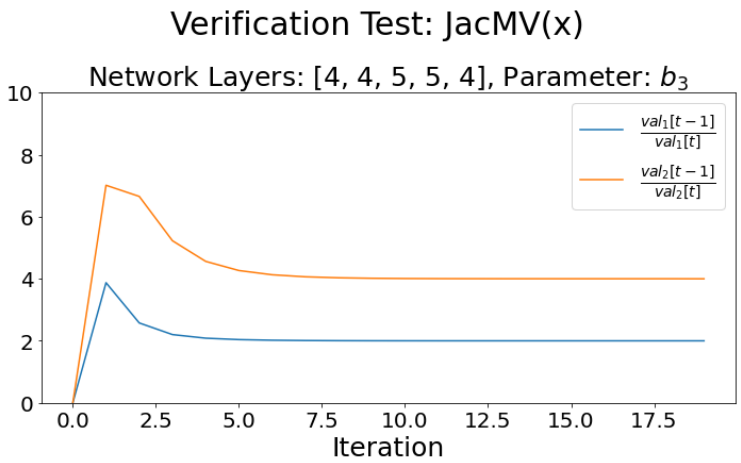

Verification Test: JacMV(x)
Network Layers: [4, 4, 5, 5, 4], Parameter: w_1
$\frac{val_1[t-1]}{val_1[t]}$
$\frac{val_2[t-1]}{val_2[t]}$
0
2
4
6
8
10
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
Iteration


Verification Test: JacMV(x)
Network Layers: [4, 4, 5, 5, 4], Parameter: b_1
$\frac{val_1[t-1]}{val_1[t]}$
$\frac{val_2[t-1]}{val_2[t]}$
0
2
4
6
8
10
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
Iteration


Verification Test: JacMV(x)
Network Layers: [4, 4, 5, 5, 4], Parameter: w_2
$\frac{val_1[t-1]}{val_1[t]}$
$\frac{val_2[t-1]}{val_2[t]}$
0
2
4
6
8
10
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
Iteration


Verification Test: JacMV(x)
Network Layers: [4, 4, 5, 5, 4], Parameter: b_2
$\frac{val_1[t-1]}{val_1[t]}$
$\frac{val_2[t-1]}{val_2[t]}$
0
2
4
6
8
10
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
Iteration


Verification Test: JacMV(x)
Network Layers: [4, 4, 5, 5, 4], Parameter: w_3
$\frac{val_1[t-1]}{val_1[t]}$
$\frac{val_2[t-1]}{val_2[t]}$
0
2
4
6
8
10
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
Iteration

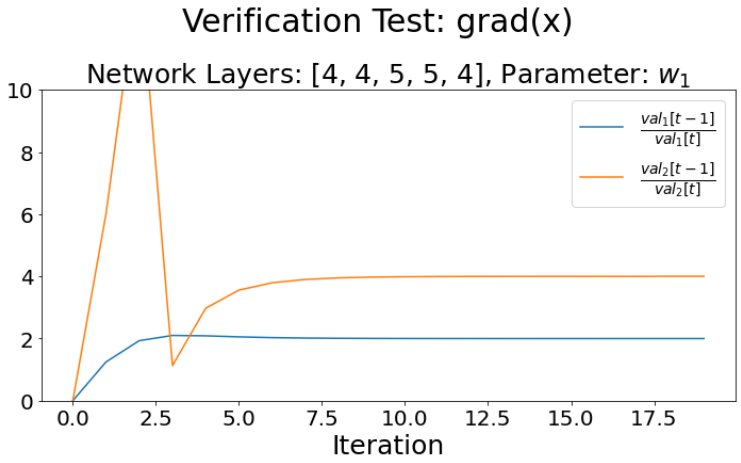

Verification Test: JacMV(x)
Network Layers: [4, 4, 5, 5, 4], Parameter: b_3
$\frac{val_1[t-1]}{val_1[t]}$
$\frac{val_2[t-1]}{val_2[t]}$
0
2
4
6
8
10
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
Iteration

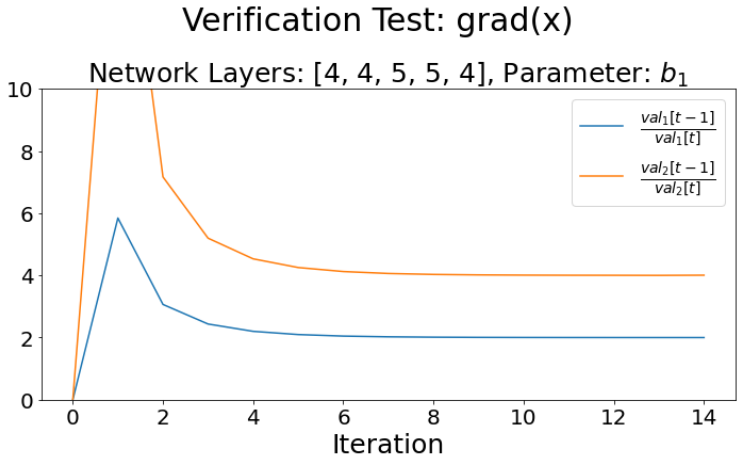
Task 6

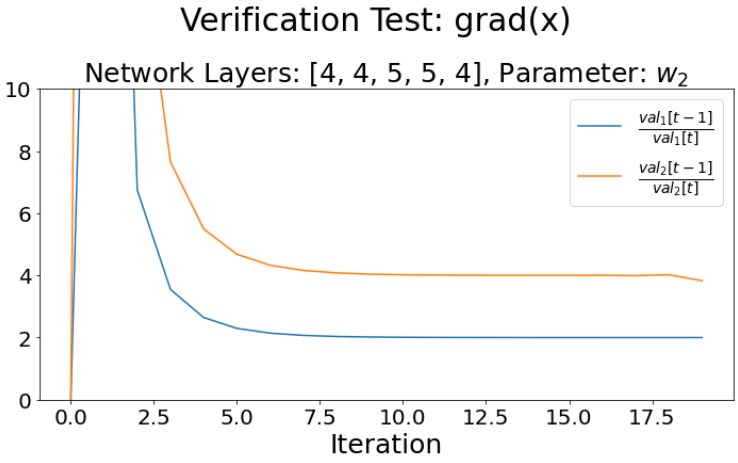
Gradient Tests: several hidden layer

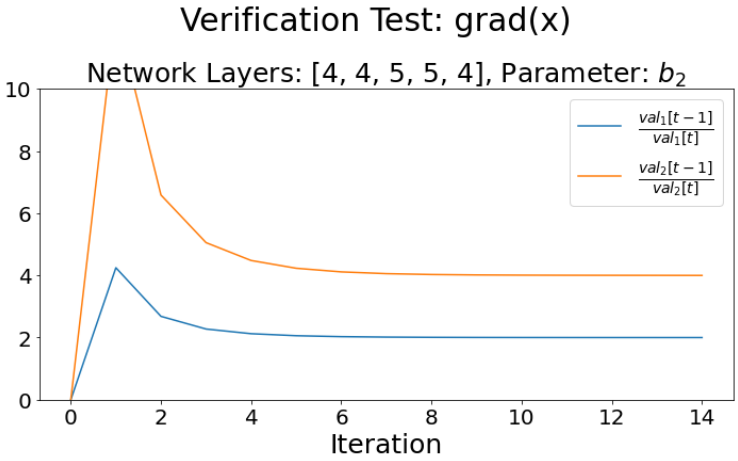
We perform the gradient test on $\frac{\partial F}{\partial w_l}, \frac{\partial F}{\partial b_l}$ for all layers $l \in \{1, ..., L\}$.

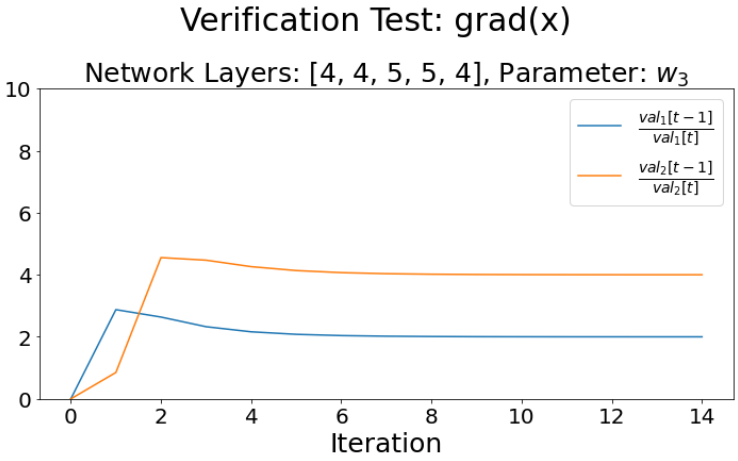
[12]:
```
from tests import gradient_test_for_all_params
gradient_test_for_all_params(input_dim, output_dim, samples=1,
                             hidden_layers_sizes=hidden_layers_for_tests, iters=20,␣
 ↪optimizer='None')
```

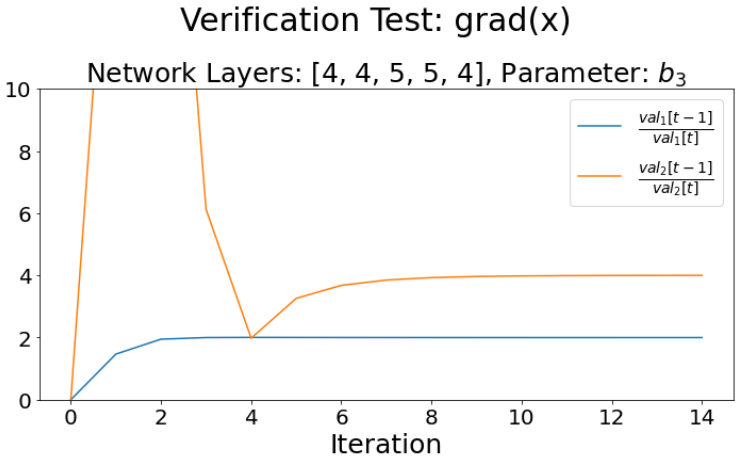


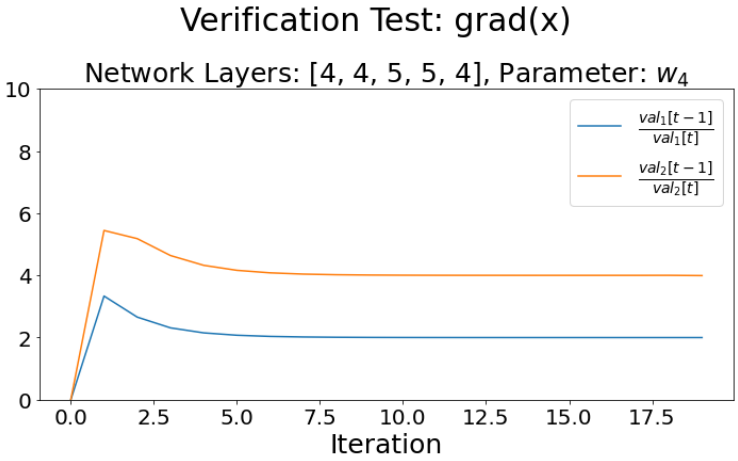


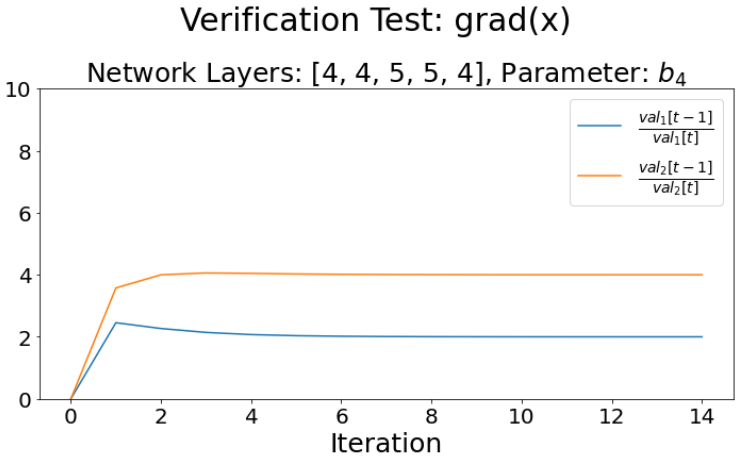

Verification Test: grad(x)
Network Layers: [4, 4, 5, 5, 4], Parameter: w_2
$\frac{val_1[t-1]}{val_1[t]}$
$\frac{val_2[t-1]}{val_2[t]}$
Iteration


Verification Test: grad(x)
Network Layers: [4, 4, 5, 5, 4], Parameter: b_2
$\frac{val_1[t-1]}{val_1[t]}$
$\frac{val_2[t-1]}{val_2[t]}$
Iteration


Verification Test: grad(x)
Network Layers: [4, 4, 5, 5, 4], Parameter: w_3
$\frac{val_1[t-1]}{val_1[t]}$
$\frac{val_2[t-1]}{val_2[t]}$
Iteration


Verification Test: grad(x)
Network Layers: [4, 4, 5, 5, 4], Parameter: b_3
$\frac{val_1[t-1]}{val_1[t]}$
$\frac{val_2[t-1]}{val_2[t]}$
Iteration


Verification Test: grad(x)
Network Layers: [4, 4, 5, 5, 4], Parameter: w_4
$\frac{val_1[t-1]}{val_1[t]}$
$\frac{val_2[t-1]}{val_2[t]}$
Iteration

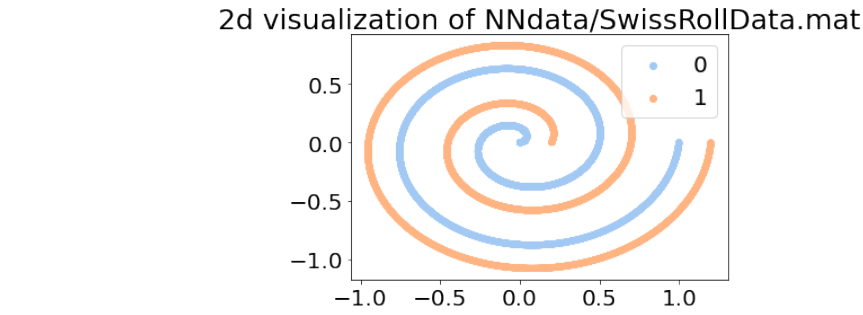

Verification Test: grad(x)
Network Layers: [4, 4, 5, 5, 4], Parameter: b_4
$\frac{val_1[t-1]}{val_1[t]}$
$\frac{val_2[t-1]}{val_2[t]}$
Iteration

Task 7

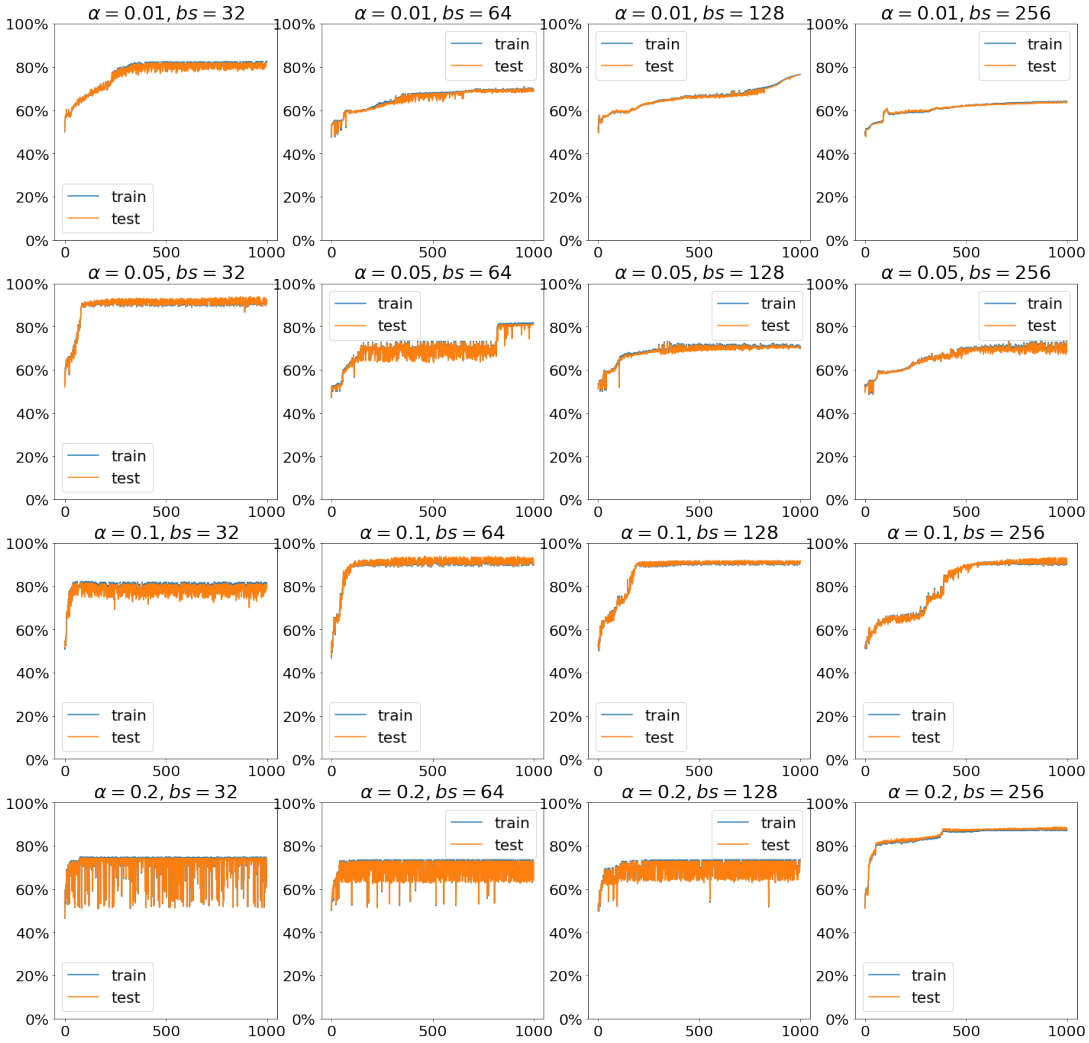
Execute SGD: several hidden layers

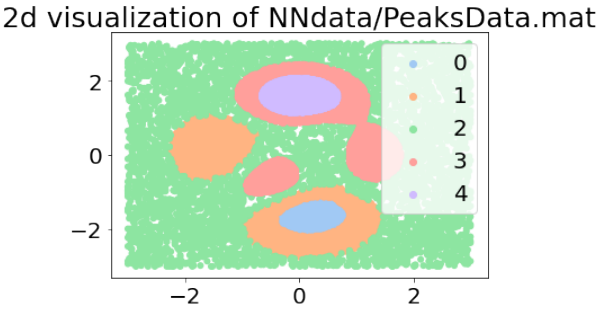
We repeat Task 3 for a multi-layer network:

[13]:
```
HIDDEN_LAYERS_FOR_DATASET = {
    'NNdata/SwissRollData.mat': [20, 10],
    'NNdata/PeaksData.mat': [6, 10],
    'NNdata/GMMData.mat': [20, 10, 5]
}
run_part_3(learning_rates=(0.01, 0.05, 0.1, 0.2),
           batch_sizes=(32, 64, 128, 256),
           hidden_layers_for_dataset=HIDDEN_LAYERS_FOR_DATASET,
           iters=1000)
```

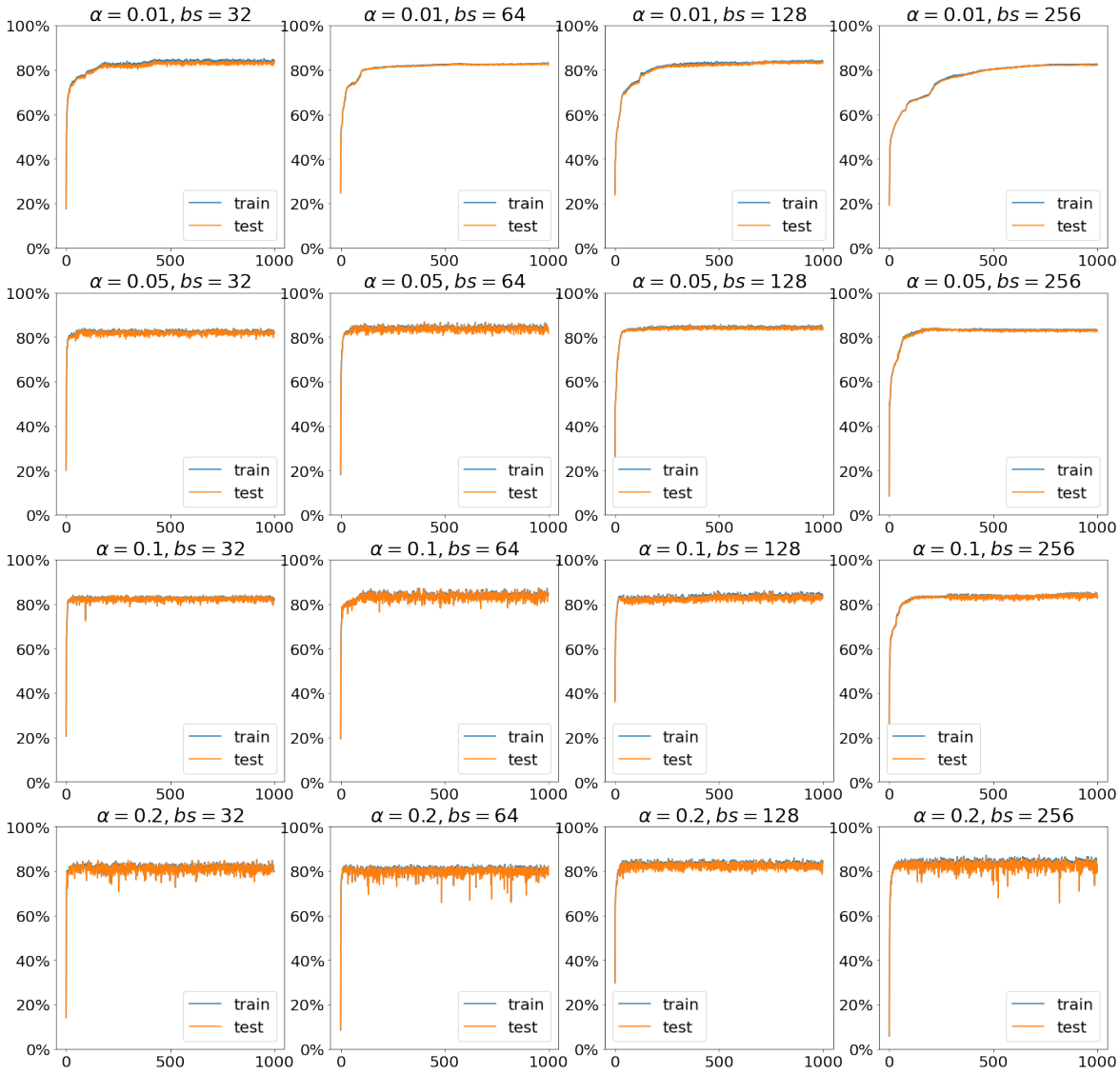


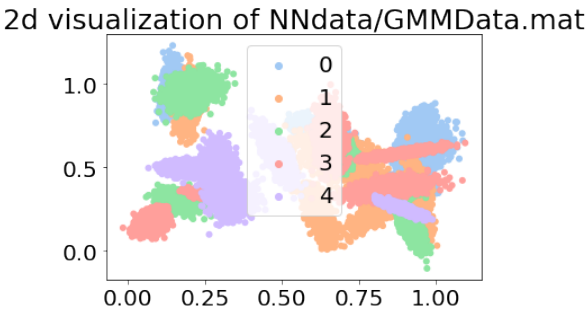
Accuracy vs. Epoch
Dataset: NNdata/SwissRollData.mat, Network Layers: [20, 10]



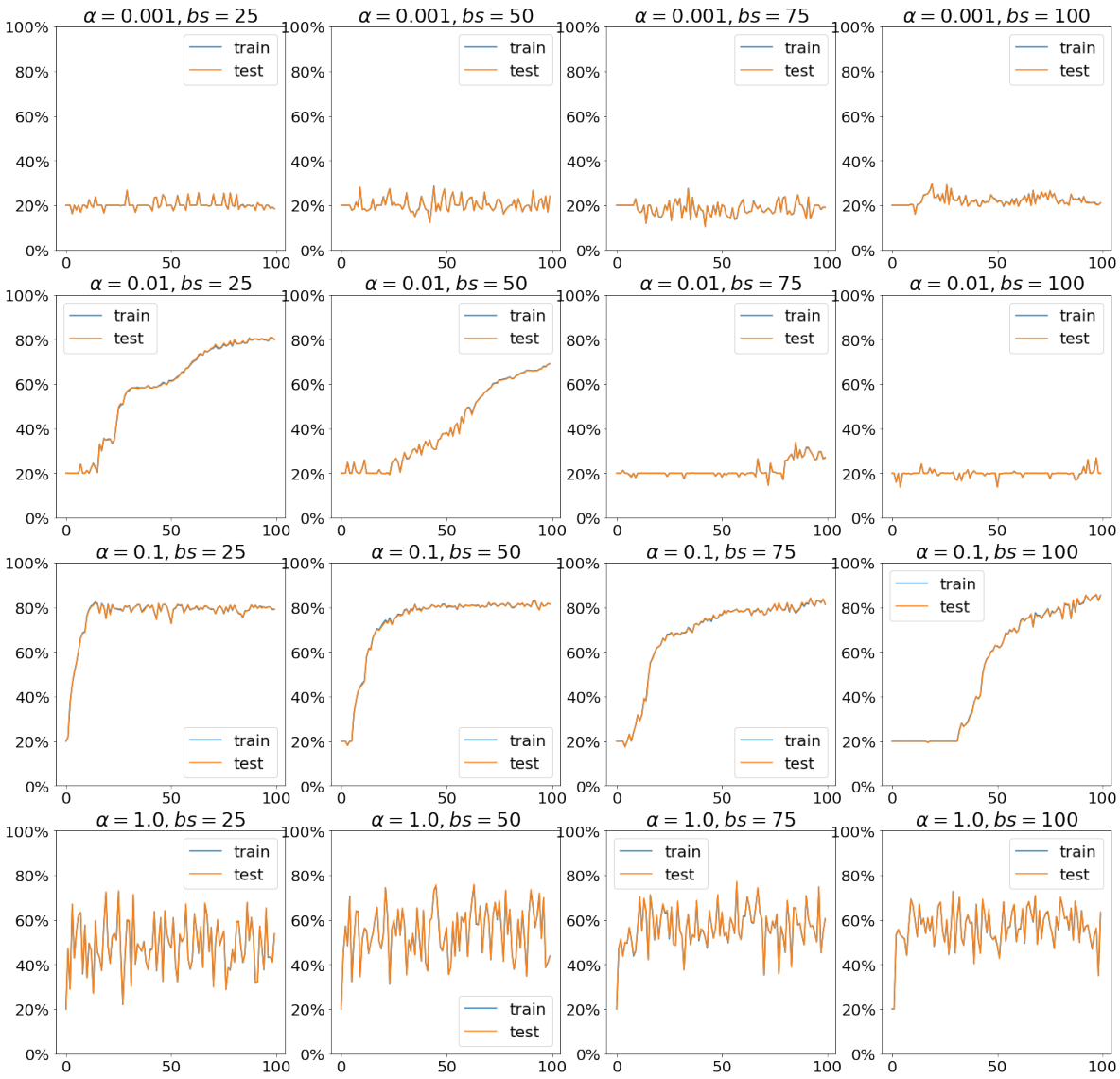


Accuracy vs. Epoch
Dataset: NNdata/PeaksData.mat, Network Layers: [6, 10]





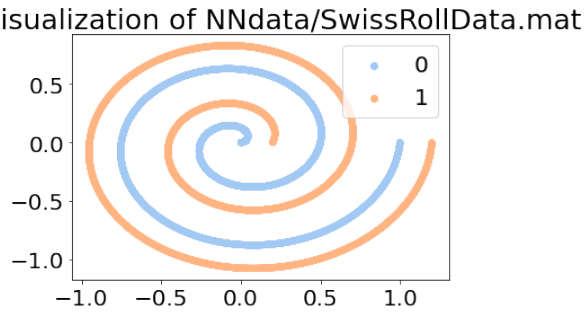
Accuracy vs. Epoch
Dataset: NNdata/GMMData.mat, Network Layers: [6, 10]



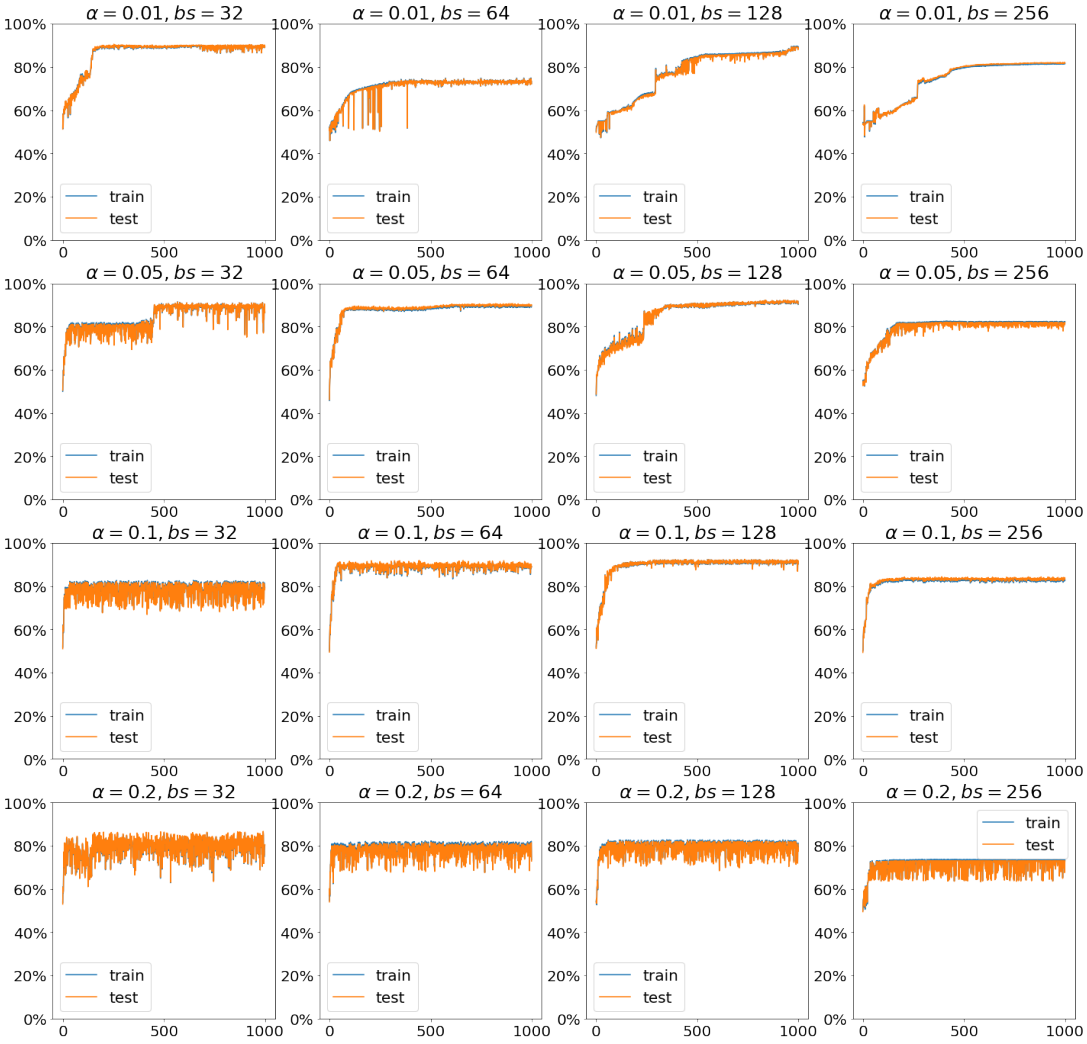
Ablation Study: SGD with momentum

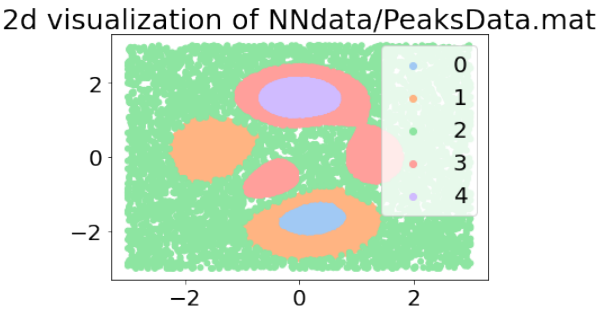
We run SGD with momentum:

[14]:
```
run_part_3(learning_rates=(0.01, 0.05, 0.1, 0.2),
           batch_sizes=(32, 64, 128, 256),
           hidden_layers_for_dataset=HIDDEN_LAYERS_FOR_DATASET,
           iters=1000,
           optimizer='momentum',
           gamma=0.7)
```

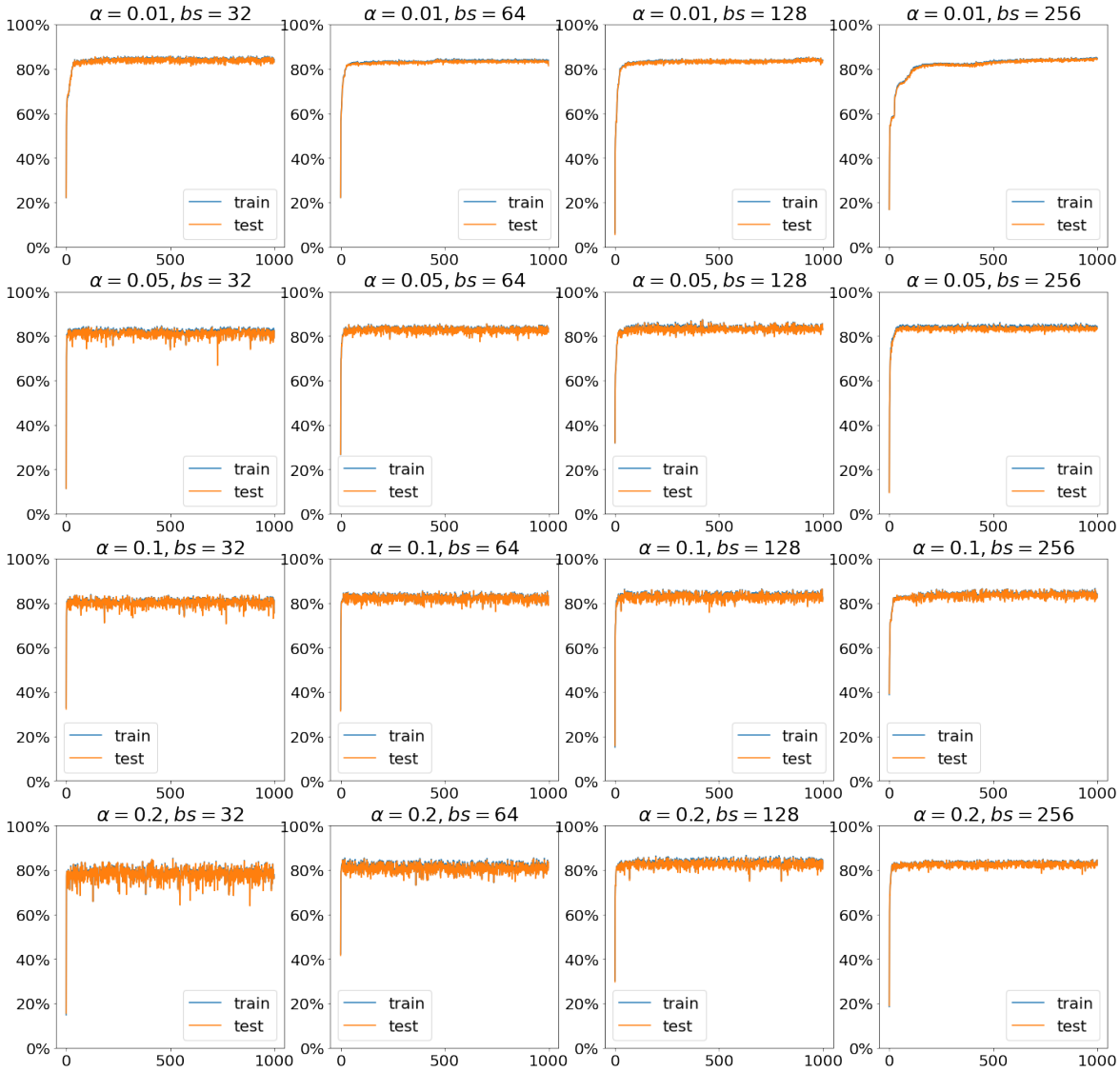


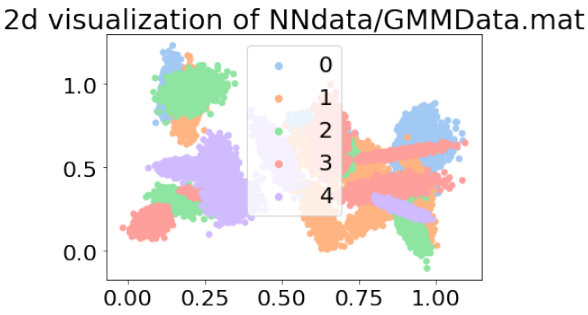
Accuracy vs. Epoch
Dataset: NNdata/SwissRollData.mat, Network Layers: [20, 10]





Accuracy vs. Epoch
Dataset: NNdata/PeaksData.mat, Network Layers: [6, 10]





Accuracy vs. Epoch
Dataset: NNdata/GMMData.mat, Network Layers: [6, 10]