CS221 Programming Assignment 2 README

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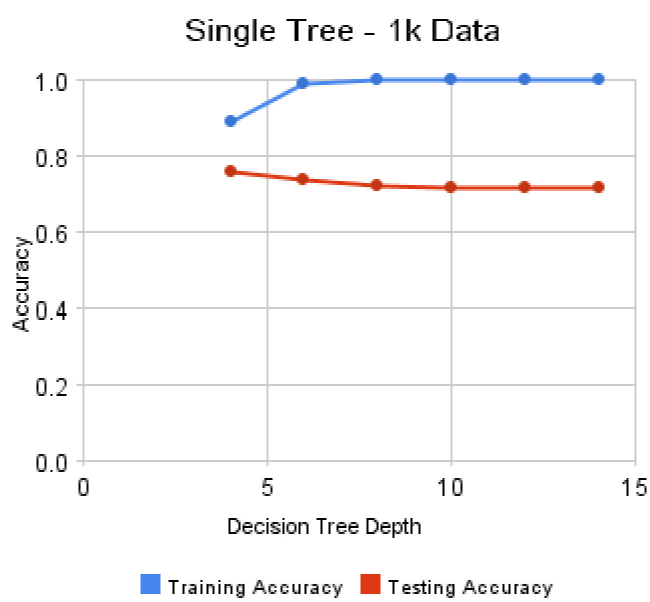
1. Growing Decision Trees

The following table and graphical representation show the accuracy of the single tree algorithm with 1k of training data:

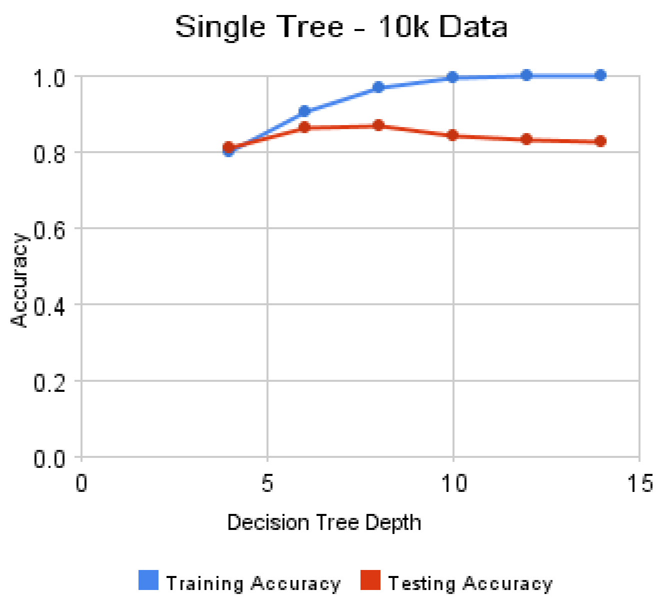
Depth	Training Accuracy	Testing Accuracy
4	.888	.759
6	.989	.737
8	.999	.721
10	1	.715
12	1	.717
14	1	.717



Here we notice that the training accuracy increases with complexity, while the test accuracy decreases with increasing complexity, indicating that we may be overfitting the data. This suggests that we are in the high-variance zone, and providing more training data might help.

The following table and graphical representation show the accuracy of the single tree algorithm with 10k of training data:

Depth	Training Accuracy	Testing Accuracy
4	.8	.808
6	.906	.864
8	.9681	.866
10	.9958	.84
12	.9997	.831
14	1	.827

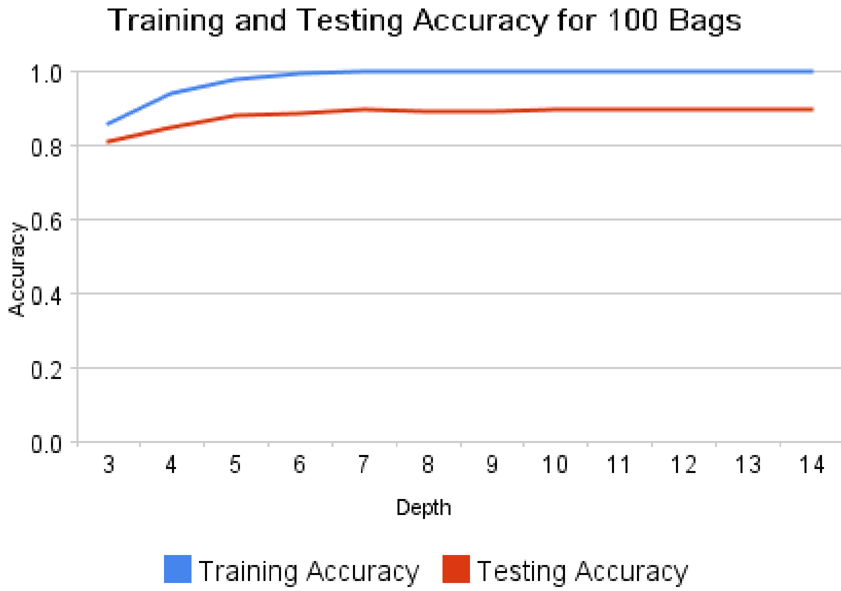


With 10k of data, training accuracy improves as well, with increasing tree depth. However unlike with the 1k data, where the test accuracy constantly decreased, here the testing accuracy improves as well, peaks at depth of 8 and deteriorates after that. This indicates that with 10k of data, we are initially in the high bias zone (at depth 4) and move into the high variance zone (at depth 14). An optimal depth is thus in-between, around 8, where we get the most test accuracy.

2. Bagging

The following table and graphical representation show the accuracy of the bagging algorithm:

Depth	Training Accuracy	Testing Accuracy
3	.862	.809
4	.938	.849
5	.98	.881
6	.995	.889
7	1	.897
8	1	.894
9	1	.894
10	1	.895
11	1	.895
12	1	.896
13	1	.896
14	1	.896



The performance of the bagged classifier is a significant improvement on the single decision tree. Also, as the training accuracy increases, the testing accuracy also increases, which is a different result than the single decision tree. This shows that bagging has eliminated the problem of high variance that was present with single decision trees.

Code Overview

We implemented a single decision tree.
The algorithm works as follows:

- We recursively create the tree, finding the pixel with the maximum information gain to split on, and ending the recursion when depth = max-depth specified.
- To find the best threshold value for a given pixel, we compute the information gain at threshold levels .1 through .9 at intervals of .1 and find the value that maximizes the information gain for a given pixel
- Information gain is calculated using the entropy function, H
    - Information Gain = (Entropy before the split) - (total examples above threshold) * H(positive examples classified correctly/total examples above threshold) - (total examples below threshold) H(positive examples classified incorrectly/total examples below threshold)
    - H: -(p*LogBaseTwo(p)+(1-p)*LogBaseTwo(1-p))

We implemented bagging using our single decision tree implementation.
The algorithm works as follows:

- We create B bags (decision trees)

- For each bag, we sample N training examples, with replacement, from our original N training examples and use these to create the tree
- During classification, we use the majority vote of the B bags to classify the example

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3. Extensions

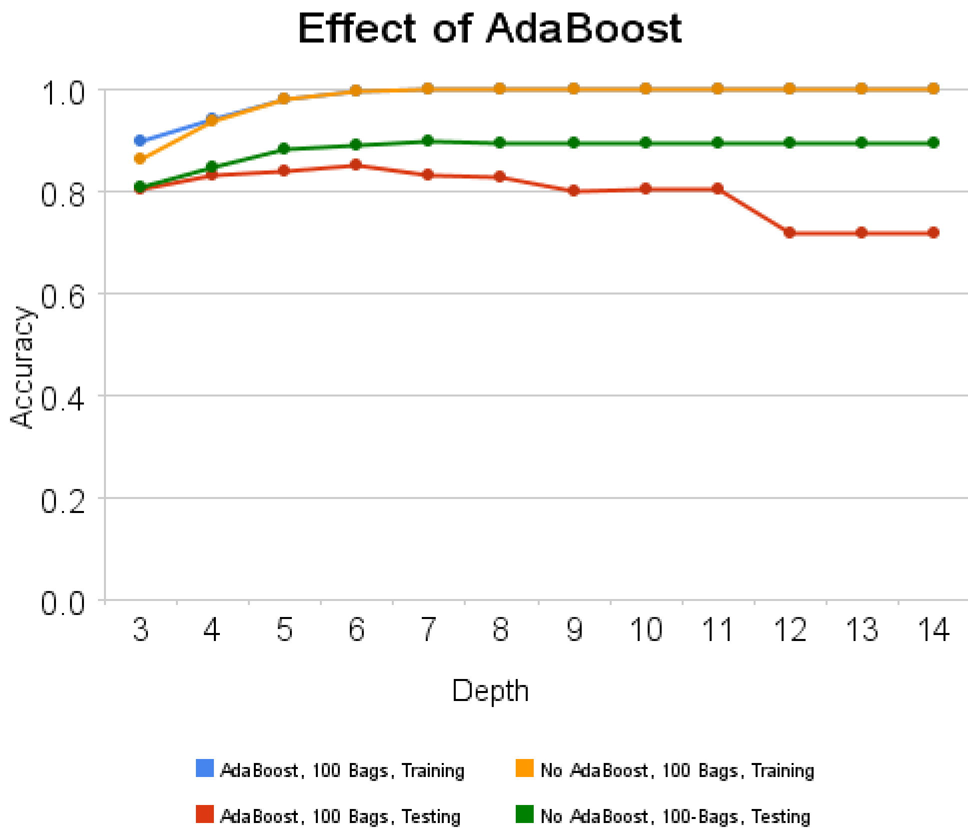
AdaBoost

We implemented an AdaBoost based BoostingDecisionTree. To run this, use the word "boosting" instead of "bagging" in the command line for digit:
$ ./digit **boosting** training-1k-images.idx3 training-1k-labels.idx1 test-1k-images.idx3 test-1k-labels.idx1 <tree-depth> <max-ensemble-size> <classifier-outfile>

Alternatively you can use the script task3.sh (no arguments necessary) to run a series of tests on many depths.

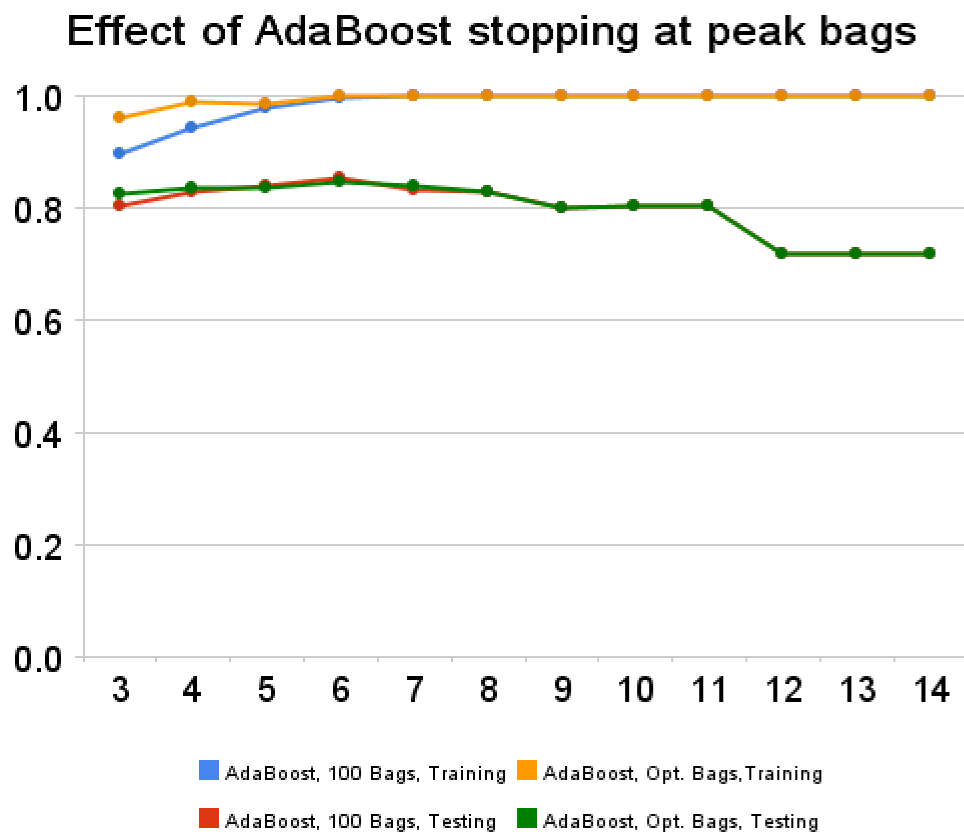
The results of running this with 100 bags are shown below (with and without boosting). We notice that boosting improves training accuracies even at very small depths. We also notice that as depth increases, the test accuracy deteriorates with boosting.

Depth	AdaBoost, 100 Bags, Training	AdaBoost, 100 Bags, Testing	No AdaBoost, 100 Bags, Training	No AdaBoost, 100-Bags, Testing
3	0.898	0.802	0.862	0.809
4	0.942	0.83	0.938	0.849
5	0.98	0.841	0.98	0.881
6	0.998	0.852	0.995	0.889
7	0.999	0.832	1	0.897
8	0.999	0.829	1	0.894
9	1	0.799	1	0.894
10	1	0.803	1	0.895
11	1	0.802	1	0.895
12	1	0.718	1	0.896
13	1	0.718	1	0.896
14	1	0.718	1	0.896



The hunch here was that the 100 bags were not really doing anything (after it was getting all the training examples right, there are no incorrect examples with which to construct the remaining bags, so we use uniform distribution for those) useful, so we stopped with the bags that produced peak training error. This is summarized below:

Depth	**AdaBoost, 100 Bags, Training**	**AdaBoost, 100 Bags, Testing**	**AdaBoost, Opt. Bags,Training**	**AdaBoost, Opt. Bags, Testing**	**Peak Bags**
3	0.898	0.802	0.96	0.824	57
4	0.942	0.83	0.988	0.837	35
5	0.98	0.841	0.986	0.835	16
6	0.998	0.852	1	0.848	16
7	0.999	0.832	1	0.841	3
8	0.999	0.829	1	0.828	4
9	1	0.799	1	0.799	2
10	1	0.803	1	0.803	2
11	1	0.802	1	0.802	2
12	1	0.718	1	0.718	1
13	1	0.718	1	0.718	1
14	1	0.718	1	0.718	1



This produced better training and test accuracies for lower depths and then caused it to again produced deterioration of testing error with increasing depths owing we think to overfitting of the boosting algorithm. If our implementation of the algorithm is correct, Boosting seems to work best with minimal features. The code for this is located in BoostedDecisionTree.h/.c.

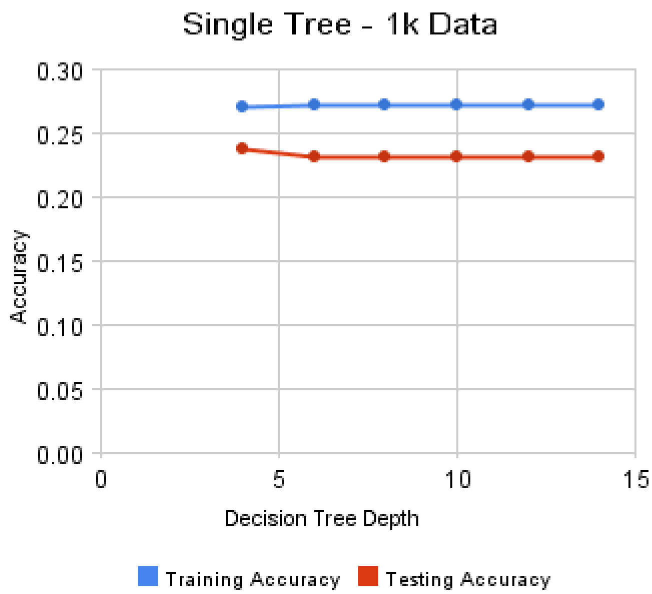
New Feature

We decided to use the average of all pixels in the digit as the only feature, instead of using individual pixels as features. The code file for this is DecisionTree1.c.

The following table and graphical representation show the accuracy of the single tree algorithm with 1k of training data:

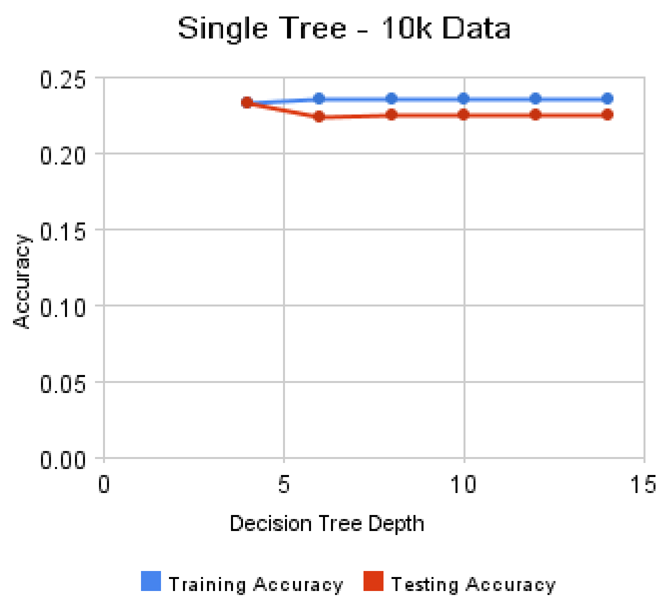
Depth	Training Accuracy	Testing Accuracy
4	.27	.238

6	.272	.232
8	.272	.232
10	.272	.232
12	.272	.232
14	.272	.232



The following table and graphical representation show the accuracy of the single tree algorithm with 10k of training data:

Depth	Training Accuracy	Testing Accuracy
4	.2333	.233
6	.2354	.224
8	.2359	.225
10	.2359	.225
12	.2359	.225
14	.2359	.225



The performance of the classifier, using a single feature, the average of the pixels, has significantly worse accuracy. The training and test accuracy are similar, showing that there is high bias. Combining this with the original features could be a way to potentially improve accuracy.

Output

```
Task1

./task1.sh
Depth: 4, Trained on 1k
./digit singletree /afs/ir/class/cs221/data/digits/training-1k-images.idx3
/afs/ir/class/cs221/data/digits/training-1k-labels.idx1 /afs/ir/class/cs221/
data/digits/test-1k-images.idx3 /afs/ir/class/cs221/data/digits/test-1k-
labels.idx1 4 singleTree1k4.out
...1000...900...800...700...600...500...400...300...200...100
...1000...900...800...700...600...500...400...300...200...100
Depth: 6, Trained on 1k
./digit singletree /afs/ir/class/cs221/data/digits/training-1k-images.idx3
/afs/ir/class/cs221/data/digits/training-1k-labels.idx1 /afs/ir/class/cs221/
data/digits/test-1k-images.idx3 /afs/ir/class/cs221/data/digits/test-1k-
labels.idx1 6 singleTree1k6.out
```

```
...1000...900...800...700...600...500...400...300...200...100
...1000...900...800...700...600...500...400...300...200...100
Depth: 8, Trained on 1k
./digit singletree /afs/ir/class/cs221/data/digits/training-1k-images.idx3
/afs/ir/class/cs221/data/digits/training-1k-labels.idx1 /afs/ir/class/cs221/
data/digits/test-1k-images.idx3 /afs/ir/class/cs221/data/digits/test-1k-
labels.idx1 8 singleTree1k8.out
...1000...900...800...700...600...500...400...300...200...100
...1000...900...800...700...600...500...400...300...200...100
Depth: 10, Trained on 1k
./digit singletree /afs/ir/class/cs221/data/digits/training-1k-images.idx3
/afs/ir/class/cs221/data/digits/training-1k-labels.idx1 /afs/ir/class/cs221/
data/digits/test-1k-images.idx3 /afs/ir/class/cs221/data/digits/test-1k-
labels.idx1 10 singleTree1k10.out
...1000...900...800...700...600...500...400...300...200...100
...1000...900...800...700...600...500...400...300...200...100
Depth: 12, Trained on 1k
./digit singletree /afs/ir/class/cs221/data/digits/training-1k-images.idx3
/afs/ir/class/cs221/data/digits/training-1k-labels.idx1 /afs/ir/class/cs221/
data/digits/test-1k-images.idx3 /afs/ir/class/cs221/data/digits/test-1k-
labels.idx1 12 singleTree1k12.out
...1000...900...800...700...600...500...400...300...200...100
...1000...900...800...700...600...500...400...300...200...100
Depth: 14, Trained on 1k
./digit singletree /afs/ir/class/cs221/data/digits/training-1k-images.idx3
/afs/ir/class/cs221/data/digits/training-1k-labels.idx1 /afs/ir/class/cs221/
data/digits/test-1k-images.idx3 /afs/ir/class/cs221/data/digits/test-1k-
labels.idx1 14 singleTree1k14.out
...1000...900...800...700...600...500...400...300...200...100
...1000...900...800...700...600...500...400...300...200...100
Depth: 4, Trained on 10k
./digit singletree /afs/ir/class/cs221/data/digits/training-10k-images.idx3
/afs/ir/class/cs221/data/digits/training-10k-labels.idx1 /afs/ir/class/cs221/
data/digits/test-1k-images.idx3 /afs/ir/class/cs221/data/digits/test-1k-
labels.idx1 4 singleTree10k4.out
...10000...9900...9800...9700...9600...9500...9400...9300...9200...9100...9000...8900...88
...1000...900...800...700...600...500...400...300...200...100
Depth: 6, Trained on 10k
./digit singletree /afs/ir/class/cs221/data/digits/training-10k-images.idx3
/afs/ir/class/cs221/data/digits/training-10k-labels.idx1 /afs/ir/class/cs221/
data/digits/test-1k-images.idx3 /afs/ir/class/cs221/data/digits/test-1k-
labels.idx1 6 singleTree10k6.out
...10000...9900...9800...9700...9600...9500...9400...9300...9200...9100...9000...8900...88
...1000...900...800...700...600...500...400...300...200...100
Depth: 8, Trained on 10k
./digit singletree /afs/ir/class/cs221/data/digits/training-10k-images.idx3
/afs/ir/class/cs221/data/digits/training-10k-labels.idx1 /afs/ir/class/cs221/
data/digits/test-1k-images.idx3 /afs/ir/class/cs221/data/digits/test-1k-
labels.idx1 8 singleTree10k8.out
...10000...9900...9800...9700...9600...9500...9400...9300...9200...9100...9000...8900...88
...1000...900...800...700...600...500...400...300...200...100
Depth: 10, Trained on 10k
./digit singletree /afs/ir/class/cs221/data/digits/training-10k-images.idx3
/afs/ir/class/cs221/data/digits/training-10k-labels.idx1 /afs/ir/class/cs221/
```

```
data/digits/test-1k-images.idx3 /afs/ir/class/cs221/data/digits/test-1k-
labels.idx1 10 singleTree10k10.out
...10000...9900...9800...9700...9600...9500...9400...9300...9200...9100...9000...8900...88
...1000...900...800...700...600...500...400...300...200...100
Depth: 12, Trained on 10k
./digit singletree /afs/ir/class/cs221/data/digits/training-10k-images.idx3
/afs/ir/class/cs221/data/digits/training-10k-labels.idx1 /afs/ir/class/cs221/
data/digits/test-1k-images.idx3 /afs/ir/class/cs221/data/digits/test-1k-
labels.idx1 12 singleTree10k12.out
...10000...9900...9800...9700...9600...9500...9400...9300...9200...9100...9000...8900...88
...1000...900...800...700...600...500...400...300...200...100
Depth: 14, Trained on 10k
./digit singletree /afs/ir/class/cs221/data/digits/training-10k-images.idx3
/afs/ir/class/cs221/data/digits/training-10k-labels.idx1 /afs/ir/class/cs221/
data/digits/test-1k-images.idx3 /afs/ir/class/cs221/data/digits/test-1k-
labels.idx1 14 singleTree10k14.out
...10000...9900...9800...9700...9600...9500...9400...9300...9200...9100...9000...8900...88
...1000...900...800...700...600...500...400...300...200...100

Accuracies for 1k:
On train data:
Depth: 4
0 0.888
Depth: 6
0 0.989
Depth: 8
0 0.999
Depth: 10
0 1
Depth: 12
0 1
Depth: 14
0 1
On test data:
Depth: 4
0 0.759
Depth: 6
0 0.737
Depth: 8
0 0.721
Depth: 10
0 0.715
Depth: 12
0 0.717
Depth: 14
0 0.717

Accuracies for 10k:
On train data:
Depth: 4
0 0.8
Depth: 6
0 0.906
Depth: 8
```

```
0 0.9681
Depth: 10
0 0.9958
Depth: 12
0 0.9997
Depth: 14
0 1
On test data:
Depth: 4
0 0.808
Depth: 6
0 0.864
Depth: 8
0 0.866
Depth: 10
0 0.84
Depth: 12
0 0.831
Depth: 14
0 0.827
Accuracies also logged to tmp.log
```

Task2

```
--- results.bagdt.training.d3.txt ---
0 0.641
1 0.757
2 0.798
3 0.832
4 0.85
5 0.855
6 0.86
7 0.855
8 0.856
9 0.856
10 0.86
11 0.863
12 0.86
13 0.859
14 0.86
15 0.863
16 0.865
17 0.865
18 0.864
19 0.867
20 0.863
21 0.865
22 0.867
23 0.863
24 0.861
25 0.863
```

26 0.865
27 0.865
28 0.866
29 0.866
30 0.864
31 0.869
32 0.866
33 0.864
34 0.867
35 0.862
36 0.865
37 0.863
38 0.86
39 0.862
40 0.861
41 0.863
42 0.862
43 0.86
44 0.862
45 0.859
46 0.859
47 0.86
48 0.859
49 0.859
50 0.858
51 0.859
52 0.86
53 0.86
54 0.858
55 0.859
56 0.859
57 0.858
58 0.858
59 0.859
60 0.859
61 0.858
62 0.859
63 0.859
64 0.861
65 0.861
66 0.862
67 0.863
68 0.863
69 0.863
70 0.863
71 0.863
72 0.861
73 0.86
74 0.861
75 0.86
76 0.86
77 0.86
78 0.86
79 0.86

80 0.86
81 0.86
82 0.86
83 0.859
84 0.861
85 0.861
86 0.86
87 0.86
88 0.86
89 0.862
90 0.861
91 0.862
92 0.862
93 0.863
94 0.863
95 0.862
96 0.862
97 0.862
98 0.862
99 0.862
--- results.bagdt.training.d4.txt ---
0 0.704
1 0.796
2 0.862
3 0.876
4 0.89
5 0.903
6 0.91
7 0.914
8 0.916
9 0.922
10 0.923
11 0.923
12 0.923
13 0.926
14 0.927
15 0.927
16 0.925
17 0.924
18 0.923
19 0.925
20 0.927
21 0.926
22 0.928
23 0.929
24 0.93
25 0.929
26 0.934
27 0.935
28 0.936
29 0.934
30 0.934
31 0.934
32 0.933

33	0.935
34	0.934
35	0.936
36	0.934
37	0.933
38	0.933
39	0.932
40	0.934
41	0.933
42	0.932
43	0.933
44	0.932
45	0.932
46	0.931
47	0.932
48	0.933
49	0.934
50	0.932
51	0.931
52	0.932
53	0.935
54	0.935
55	0.933
56	0.935
57	0.938
58	0.936
59	0.938
60	0.938
61	0.937
62	0.937
63	0.936
64	0.935
65	0.936
66	0.935
67	0.936
68	0.936
69	0.937
70	0.937
71	0.939
72	0.939
73	0.936
74	0.935
75	0.935
76	0.936
77	0.936
78	0.936
79	0.935
80	0.938
81	0.937
82	0.936
83	0.937
84	0.935
85	0.939
86	0.938

```
87 0.938
88 0.938
89 0.938
90 0.938
91 0.937
92 0.937
93 0.937
94 0.937
95 0.937
96 0.937
97 0.938
98 0.938
99 0.938
--- results.bagdt.training.d5.txt ---
0 0.774
1 0.895
2 0.933
3 0.946
4 0.952
5 0.96
6 0.966
7 0.972
8 0.97
9 0.971
10 0.976
11 0.975
12 0.973
13 0.974
14 0.975
15 0.979
16 0.977
17 0.979
18 0.979
19 0.98
20 0.979
21 0.977
22 0.977
23 0.974
24 0.975
25 0.975
26 0.974
27 0.974
28 0.975
29 0.975
30 0.975
31 0.976
32 0.976
33 0.977
34 0.975
35 0.975
36 0.975
37 0.975
38 0.976
39 0.976
```

40	0.977
41	0.976
42	0.976
43	0.975
44	0.975
45	0.974
46	0.973
47	0.973
48	0.974
49	0.974
50	0.974
51	0.974
52	0.974
53	0.975
54	0.975
55	0.976
56	0.975
57	0.975
58	0.974
59	0.975
60	0.976
61	0.976
62	0.977
63	0.977
64	0.977
65	0.977
66	0.976
67	0.975
68	0.975
69	0.977
70	0.977
71	0.976
72	0.976
73	0.976
74	0.976
75	0.975
76	0.977
77	0.976
78	0.978
79	0.978
80	0.978
81	0.978
82	0.978
83	0.978
84	0.979
85	0.98
86	0.98
87	0.98
88	0.98
89	0.98
90	0.98
91	0.98
92	0.98
93	0.98

```
94 0.98
95 0.98
96 0.98
97 0.98
98 0.98
99 0.98
--- results.bagdt.training.d6.txt ---
0 0.823
1 0.931
2 0.951
3 0.97
4 0.975
5 0.979
6 0.987
7 0.987
8 0.99
9 0.993
10 0.994
11 0.993
12 0.994
13 0.995
14 0.995
15 0.995
16 0.996
17 0.994
18 0.996
19 0.998
20 0.997
21 0.996
22 0.998
23 0.998
24 0.996
25 0.996
26 0.997
27 0.997
28 0.998
29 0.997
30 0.996
31 0.996
32 0.996
33 0.997
34 0.996
35 0.996
36 0.996
37 0.996
38 0.996
39 0.996
40 0.996
41 0.995
42 0.995
43 0.995
44 0.995
45 0.995
46 0.995
```

```
47 0.995
48 0.995
49 0.996
50 0.995
51 0.997
52 0.997
53 0.997
54 0.996
55 0.996
56 0.996
57 0.996
58 0.996
59 0.996
60 0.996
61 0.996
62 0.996
63 0.996
64 0.996
65 0.996
66 0.996
67 0.996
68 0.996
69 0.996
70 0.996
71 0.997
72 0.996
73 0.997
74 0.997
75 0.997
76 0.997
77 0.997
78 0.997
79 0.997
80 0.997
81 0.997
82 0.996
83 0.996
84 0.996
85 0.996
86 0.996
87 0.995
88 0.995
89 0.995
90 0.995
91 0.995
92 0.995
93 0.996
94 0.996
95 0.996
96 0.996
97 0.996
98 0.995
99 0.995
--- results.bagdt.training.d7.txt ---
```

0 0.849
1 0.946
2 0.969
3 0.987
4 0.99
5 0.996
6 0.997
7 0.998
8 0.999
9 0.999
10 0.998
11 0.998
12 0.998
13 0.999
14 0.998
15 0.999
16 0.999
17 0.998
18 0.999
19 0.999
20 1
21 1
22 1
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91 1
92 1
93 1
94 1
95 1
96 1
97 1
98 1
99 1
--- results.bagdt.training.d8.txt ---
0 0.874
1 0.958
2 0.979
3 0.992
4 0.994
5 0.998
6 0.999

7 0.999
8 0.999
9 1
10 1
11 1
12 0.999
13 1
14 0.999
15 0.999
16 1
17 1
18 1
19 1
20 1
21 1
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88 1
89 1
90 1
91 1
92 1
93 1
94 1
95 1
96 1
97 1
98 1
99 1
--- results.bagdt.training.d9.txt ---
0 0.875
1 0.961
2 0.98
3 0.994
4 0.995
5 0.998
6 0.999
7 0.999
8 0.999
9 1
10 1
11 1
12 0.999
13 1

14 0.999
15 0.999
16 1
17 1
18 1
19 1
20 1
21 1
22 1
23 1
24 1
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26 1
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88 1
89 1
90 1
91 1
92 1
93 1
94 1
95 1
96 1
97 1
98 1
99 1
--- results.bagdt.training.d10.txt ---
0 0.874
1 0.961
2 0.982
3 0.994
4 0.995
5 0.998
6 0.999
7 0.999
8 0.999
9 1
10 1
11 1
12 1
13 1
14 1
15 1
16 1
17 1
18 1
19 1
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88 1
89 1
90 1
91 1
92 1
93 1
94 1
95 1
96 1
97 1
98 1
99 1
--- results.bagdt.training.d11.txt ---
0 0.874
1 0.961
2 0.982
3 0.994
4 0.995
5 0.998
6 0.999
7 0.999
8 0.999
9 1
10 1
11 1
12 1
13 1
14 1
15 1
16 1
17 1
18 1
19 1
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21 1
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27 1
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89 1
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91 1
92 1
93 1
94 1
95 1
96 1
97 1
98 1
99 1
--- results.bagdt.training.d12.txt ---
0 0.874
1 0.961
2 0.982
3 0.994
4 0.995
5 0.998
6 0.999
7 0.999
8 0.999
9 1
10 1
11 1
12 1
13 1
14 1
15 1
16 1
17 1
18 1
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89 1
90 1
91 1
92 1
93 1
94 1
95 1
96 1
97 1
98 1
99 1
--- results.bagdt.training.d13.txt ---
0 0.874
1 0.961
2 0.982
3 0.994
4 0.995
5 0.998
6 0.999
7 0.999
8 0.999
9 1
10 1
11 1
12 1
13 1
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92 1
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95 1

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96 1
97 1
98 1
99 1
--- results.bagdt.training.d14.txt ---
0 0.874
1 0.961
2 0.982
3 0.994
4 0.995
5 0.998
6 0.999
7 0.999
8 0.999
9 1
10 1
11 1
12 1
13 1
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91 1
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93 1
94 1
95 1
96 1
97 1
98 1
99 1

Testing Accuracy from Depth 3 to 14
BagsIndex Accuracy
```

--- results.bagdt.test.d3.txt ---
0 0.543
1 0.698
2 0.727
3 0.769
4 0.785
5 0.805
6 0.803
7 0.814
8 0.816
9 0.817
10 0.814
11 0.81
12 0.812
13 0.815
14 0.814
15 0.816
16 0.824
17 0.828
18 0.825
19 0.823
20 0.821
21 0.82
22 0.82
23 0.82
24 0.819
25 0.821
26 0.818
27 0.819
28 0.816
29 0.815
30 0.812
31 0.814
32 0.81
33 0.812
34 0.81
35 0.812
36 0.813
37 0.811
38 0.813
39 0.814
40 0.815
41 0.814
42 0.814
43 0.81
44 0.808
45 0.808
46 0.808
47 0.81
48 0.809
49 0.81
50 0.812
51 0.812
52 0.813

```
53 0.813
54 0.811
55 0.813
56 0.814
57 0.815
58 0.815
59 0.814
60 0.814
61 0.813
62 0.813
63 0.813
64 0.813
65 0.813
66 0.812
67 0.812
68 0.811
69 0.812
70 0.812
71 0.811
72 0.811
73 0.811
74 0.813
75 0.812
76 0.81
77 0.811
78 0.812
79 0.81
80 0.811
81 0.812
82 0.812
83 0.812
84 0.811
85 0.812
86 0.812
87 0.812
88 0.81
89 0.81
90 0.81
91 0.81
92 0.811
93 0.81
94 0.809
95 0.808
96 0.808
97 0.809
98 0.809
99 0.809
--- results.bagdt.test.d4.txt ---
0 0.634
1 0.735
2 0.773
3 0.799
4 0.81
5 0.824
```

6 0.825
7 0.827
8 0.832
9 0.839
10 0.84
11 0.842
12 0.84
13 0.844
14 0.841
15 0.838
16 0.844
17 0.845
18 0.845
19 0.846
20 0.843
21 0.844
22 0.844
23 0.848
24 0.85
25 0.852
26 0.856
27 0.855
28 0.856
29 0.858
30 0.855
31 0.854
32 0.853
33 0.851
34 0.851
35 0.851
36 0.847
37 0.848
38 0.847
39 0.849
40 0.852
41 0.847
42 0.849
43 0.849
44 0.849
45 0.848
46 0.848
47 0.849
48 0.849
49 0.852
50 0.852
51 0.85
52 0.849
53 0.851
54 0.85
55 0.85
56 0.85
57 0.851
58 0.85
59 0.852

```
60 0.851
61 0.851
62 0.851
63 0.851
64 0.848
65 0.848
66 0.849
67 0.85
68 0.849
69 0.849
70 0.849
71 0.849
72 0.85
73 0.847
74 0.849
75 0.849
76 0.85
77 0.848
78 0.849
79 0.847
80 0.846
81 0.847
82 0.845
83 0.847
84 0.844
85 0.844
86 0.845
87 0.844
88 0.846
89 0.846
90 0.845
91 0.844
92 0.844
93 0.844
94 0.844
95 0.844
96 0.845
97 0.848
98 0.849
99 0.849
--- results.bagdt.test.d5.txt ---
0 0.676
1 0.776
2 0.804
3 0.835
4 0.844
5 0.857
6 0.87
7 0.869
8 0.867
9 0.876
10 0.872
11 0.877
12 0.875
```

13 0.875
14 0.875
15 0.877
16 0.876
17 0.877
18 0.877
19 0.884
20 0.88
21 0.88
22 0.882
23 0.879
24 0.883
25 0.883
26 0.885
27 0.884
28 0.88
29 0.88
30 0.879
31 0.877
32 0.882
33 0.883
34 0.882
35 0.882
36 0.881
37 0.887
38 0.886
39 0.885
40 0.883
41 0.883
42 0.884
43 0.883
44 0.885
45 0.884
46 0.885
47 0.885
48 0.883
49 0.884
50 0.883
51 0.883
52 0.886
53 0.886
54 0.886
55 0.887
56 0.885
57 0.885
58 0.887
59 0.886
60 0.886
61 0.885
62 0.885
63 0.888
64 0.887
65 0.887
66 0.889

67 0.89
68 0.886
69 0.887
70 0.885
71 0.883
72 0.885
73 0.887
74 0.884
75 0.885
76 0.885
77 0.884
78 0.886
79 0.884
80 0.884
81 0.883
82 0.883
83 0.882
84 0.882
85 0.883
86 0.883
87 0.883
88 0.883
89 0.885
90 0.884
91 0.883
92 0.886
93 0.883
94 0.883
95 0.884
96 0.885
97 0.881
98 0.881
99 0.881
--- results.bagdt.test.d6.txt ---
0 0.686
1 0.803
2 0.816
3 0.835
4 0.855
5 0.863
6 0.868
7 0.865
8 0.864
9 0.87
10 0.871
11 0.876
12 0.877
13 0.878
14 0.873
15 0.876
16 0.881
17 0.883
18 0.884
19 0.888

20	0.887
21	0.89
22	0.888
23	0.89
24	0.888
25	0.894
26	0.893
27	0.891
28	0.892
29	0.889
30	0.89
31	0.891
32	0.89
33	0.892
34	0.891
35	0.894
36	0.895
37	0.895
38	0.895
39	0.895
40	0.897
41	0.896
42	0.895
43	0.895
44	0.894
45	0.894
46	0.893
47	0.893
48	0.892
49	0.893
50	0.893
51	0.892
52	0.894
53	0.893
54	0.894
55	0.891
56	0.889
57	0.891
58	0.89
59	0.888
60	0.887
61	0.888
62	0.887
63	0.89
64	0.892
65	0.89
66	0.888
67	0.89
68	0.888
69	0.89
70	0.89
71	0.891
72	0.891
73	0.891

74 0.891
75 0.891
76 0.89
77 0.89
78 0.89
79 0.891
80 0.892
81 0.892
82 0.893
83 0.893
84 0.892
85 0.892
86 0.89
87 0.89
88 0.89
89 0.891
90 0.888
91 0.888
92 0.888
93 0.889
94 0.886
95 0.887
96 0.888
97 0.888
98 0.888
99 0.889
--- results.bagdt.test.d7.txt ---
0 0.684
1 0.803
2 0.824
3 0.844
4 0.87
5 0.867
6 0.872
7 0.873
8 0.872
9 0.878
10 0.88
11 0.885
12 0.888
13 0.889
14 0.889
15 0.897
16 0.893
17 0.894
18 0.896
19 0.896
20 0.899
21 0.899
22 0.897
23 0.894
24 0.894
25 0.897
26 0.898

27	0.899
28	0.897
29	0.895
30	0.897
31	0.896
32	0.899
33	0.901
34	0.9
35	0.901
36	0.899
37	0.9
38	0.901
39	0.9
40	0.899
41	0.898
42	0.897
43	0.897
44	0.897
45	0.896
46	0.897
47	0.893
48	0.899
49	0.9
50	0.901
51	0.896
52	0.896
53	0.894
54	0.895
55	0.896
56	0.897
57	0.898
58	0.901
59	0.899
60	0.899
61	0.896
62	0.896
63	0.895
64	0.896
65	0.898
66	0.898
67	0.895
68	0.894
69	0.897
70	0.895
71	0.897
72	0.897
73	0.898
74	0.899
75	0.897
76	0.895
77	0.895
78	0.896
79	0.896
80	0.897

81 0.896
82 0.896
83 0.894
84 0.894
85 0.894
86 0.895
87 0.892
88 0.893
89 0.895
90 0.894
91 0.894
92 0.894
93 0.896
94 0.896
95 0.897
96 0.897
97 0.896
98 0.896
99 0.897
--- results.bagdt.test.d8.txt ---
0 0.696
1 0.81
2 0.822
3 0.843
4 0.863
5 0.863
6 0.869
7 0.87
8 0.872
9 0.877
10 0.877
11 0.885
12 0.887
13 0.885
14 0.886
15 0.892
16 0.893
17 0.896
18 0.899
19 0.897
20 0.895
21 0.894
22 0.893
23 0.891
24 0.891
25 0.895
26 0.894
27 0.893
28 0.895
29 0.893
30 0.892
31 0.891
32 0.896
33 0.897

34 0.895
35 0.899
36 0.897
37 0.9
38 0.901
39 0.902
40 0.901
41 0.9
42 0.9
43 0.898
44 0.9
45 0.899
46 0.898
47 0.898
48 0.898
49 0.899
50 0.901
51 0.901
52 0.9
53 0.899
54 0.898
55 0.898
56 0.898
57 0.898
58 0.9
59 0.9
60 0.901
61 0.897
62 0.897
63 0.898
64 0.898
65 0.898
66 0.898
67 0.897
68 0.895
69 0.896
70 0.898
71 0.897
72 0.897
73 0.898
74 0.898
75 0.896
76 0.896
77 0.893
78 0.894
79 0.893
80 0.893
81 0.894
82 0.894
83 0.894
84 0.894
85 0.896
86 0.896
87 0.893

88 0.892
89 0.894
90 0.894
91 0.894
92 0.895
93 0.895
94 0.894
95 0.895
96 0.895
97 0.895
98 0.895
99 0.894
--- results.bagdt.test.d9.txt ---
0 0.697
1 0.812
2 0.824
3 0.847
4 0.869
5 0.866
6 0.869
7 0.871
8 0.873
9 0.878
10 0.879
11 0.885
12 0.889
13 0.887
14 0.885
15 0.893
16 0.894
17 0.902
18 0.901
19 0.9
20 0.898
21 0.896
22 0.895
23 0.893
24 0.894
25 0.898
26 0.895
27 0.896
28 0.898
29 0.896
30 0.895
31 0.893
32 0.898
33 0.901
34 0.898
35 0.901
36 0.899
37 0.902
38 0.901
39 0.901
40 0.9

41	0.9
42	0.902
43	0.899
44	0.9
45	0.9
46	0.9
47	0.898
48	0.9
49	0.9
50	0.903
51	0.902
52	0.9
53	0.899
54	0.897
55	0.898
56	0.899
57	0.899
58	0.902
59	0.901
60	0.902
61	0.899
62	0.899
63	0.899
64	0.898
65	0.899
66	0.898
67	0.899
68	0.897
69	0.897
70	0.899
71	0.899
72	0.899
73	0.9
74	0.899
75	0.899
76	0.898
77	0.896
78	0.896
79	0.896
80	0.896
81	0.896
82	0.893
83	0.894
84	0.895
85	0.897
86	0.897
87	0.895
88	0.893
89	0.896
90	0.896
91	0.895
92	0.897
93	0.897
94	0.896

95 0.896
96 0.896
97 0.896
98 0.895
99 0.894
--- results.bagdt.test.d10.txt ---
0 0.695
1 0.812
2 0.826
3 0.849
4 0.869
5 0.867
6 0.869
7 0.871
8 0.873
9 0.878
10 0.88
11 0.886
12 0.889
13 0.888
14 0.887
15 0.894
16 0.894
17 0.904
18 0.902
19 0.902
20 0.9
21 0.898
22 0.895
23 0.894
24 0.895
25 0.899
26 0.894
27 0.897
28 0.899
29 0.897
30 0.897
31 0.894
32 0.898
33 0.902
34 0.899
35 0.902
36 0.9
37 0.903
38 0.901
39 0.902
40 0.901
41 0.901
42 0.903
43 0.9
44 0.9
45 0.9
46 0.9
47 0.898

```
48 0.901
49 0.901
50 0.902
51 0.902
52 0.9
53 0.9
54 0.898
55 0.898
56 0.9
57 0.9
58 0.903
59 0.901
60 0.902
61 0.899
62 0.899
63 0.9
64 0.899
65 0.9
66 0.899
67 0.898
68 0.896
69 0.897
70 0.899
71 0.899
72 0.9
73 0.9
74 0.901
75 0.9
76 0.899
77 0.897
78 0.897
79 0.9
80 0.898
81 0.896
82 0.896
83 0.896
84 0.895
85 0.897
86 0.897
87 0.895
88 0.893
89 0.895
90 0.896
91 0.895
92 0.897
93 0.897
94 0.896
95 0.896
96 0.896
97 0.896
98 0.896
99 0.895
--- results.bagdt.test.d11.txt ---
0 0.695
```

1 0.812
2 0.826
3 0.848
4 0.867
5 0.865
6 0.868
7 0.871
8 0.873
9 0.878
10 0.88
11 0.886
12 0.889
13 0.888
14 0.886
15 0.893
16 0.894
17 0.903
18 0.901
19 0.901
20 0.899
21 0.897
22 0.895
23 0.894
24 0.894
25 0.899
26 0.894
27 0.897
28 0.899
29 0.897
30 0.897
31 0.894
32 0.898
33 0.902
34 0.899
35 0.902
36 0.9
37 0.903
38 0.901
39 0.902
40 0.901
41 0.901
42 0.903
43 0.9
44 0.9
45 0.899
46 0.899
47 0.897
48 0.9
49 0.901
50 0.902
51 0.901
52 0.899
53 0.899
54 0.896

```
55 0.898
56 0.898
57 0.898
58 0.902
59 0.9
60 0.901
61 0.899
62 0.898
63 0.898
64 0.897
65 0.899
66 0.897
67 0.898
68 0.896
69 0.897
70 0.899
71 0.899
72 0.899
73 0.9
74 0.9
75 0.9
76 0.899
77 0.896
78 0.897
79 0.899
80 0.897
81 0.896
82 0.896
83 0.896
84 0.895
85 0.897
86 0.897
87 0.895
88 0.893
89 0.895
90 0.895
91 0.894
92 0.896
93 0.897
94 0.896
95 0.896
96 0.896
97 0.896
98 0.896
99 0.895
--- results.bagdt.test.d12.txt ---
0 0.695
1 0.812
2 0.826
3 0.848
4 0.867
5 0.864
6 0.866
7 0.869
```

8 0.873
9 0.877
10 0.88
11 0.886
12 0.889
13 0.888
14 0.886
15 0.893
16 0.894
17 0.903
18 0.901
19 0.901
20 0.899
21 0.897
22 0.895
23 0.894
24 0.894
25 0.899
26 0.894
27 0.897
28 0.899
29 0.897
30 0.897
31 0.894
32 0.898
33 0.902
34 0.899
35 0.902
36 0.9
37 0.903
38 0.901
39 0.902
40 0.901
41 0.901
42 0.903
43 0.9
44 0.9
45 0.899
46 0.899
47 0.897
48 0.9
49 0.901
50 0.902
51 0.901
52 0.899
53 0.899
54 0.897
55 0.898
56 0.899
57 0.899
58 0.903
59 0.901
60 0.902
61 0.899

62 0.899
63 0.9
64 0.899
65 0.9
66 0.899
67 0.898
68 0.896
69 0.897
70 0.899
71 0.899
72 0.9
73 0.9
74 0.901
75 0.9
76 0.899
77 0.897
78 0.897
79 0.9
80 0.899
81 0.897
82 0.897
83 0.897
84 0.895
85 0.897
86 0.898
87 0.896
88 0.894
89 0.896
90 0.897
91 0.895
92 0.897
93 0.897
94 0.896
95 0.896
96 0.896
97 0.896
98 0.896
99 0.896
--- results.bagdt.test.d13.txt ---
0 0.695
1 0.812
2 0.826
3 0.848
4 0.867
5 0.864
6 0.866
7 0.869
8 0.873
9 0.877
10 0.88
11 0.886
12 0.889
13 0.888
14 0.886

15	0.893
16	0.894
17	0.903
18	0.901
19	0.901
20	0.899
21	0.897
22	0.895
23	0.894
24	0.894
25	0.899
26	0.894
27	0.897
28	0.899
29	0.897
30	0.897
31	0.894
32	0.898
33	0.902
34	0.899
35	0.902
36	0.9
37	0.903
38	0.901
39	0.902
40	0.901
41	0.901
42	0.903
43	0.9
44	0.9
45	0.899
46	0.899
47	0.897
48	0.9
49	0.901
50	0.902
51	0.901
52	0.899
53	0.899
54	0.897
55	0.898
56	0.899
57	0.899
58	0.903
59	0.901
60	0.902
61	0.899
62	0.899
63	0.9
64	0.899
65	0.9
66	0.899
67	0.898
68	0.896

```
69 0.897
70 0.899
71 0.899
72 0.9
73 0.9
74 0.901
75 0.9
76 0.899
77 0.897
78 0.897
79 0.9
80 0.899
81 0.897
82 0.897
83 0.897
84 0.895
85 0.897
86 0.898
87 0.896
88 0.894
89 0.896
90 0.897
91 0.895
92 0.897
93 0.897
94 0.896
95 0.896
96 0.896
97 0.896
98 0.896
99 0.896
--- results.bagdt.test.d14.txt ---
0 0.695
1 0.812
2 0.826
3 0.848
4 0.867
5 0.864
6 0.866
7 0.869
8 0.873
9 0.877
10 0.88
11 0.886
12 0.889
13 0.888
14 0.886
15 0.893
16 0.894
17 0.903
18 0.901
19 0.901
20 0.899
21 0.897
```

22	0.895
23	0.894
24	0.894
25	0.899
26	0.894
27	0.897
28	0.899
29	0.897
30	0.897
31	0.894
32	0.898
33	0.902
34	0.899
35	0.902
36	0.9
37	0.903
38	0.901
39	0.902
40	0.901
41	0.901
42	0.903
43	0.9
44	0.9
45	0.899
46	0.899
47	0.897
48	0.9
49	0.901
50	0.902
51	0.901
52	0.899
53	0.899
54	0.897
55	0.898
56	0.899
57	0.899
58	0.903
59	0.901
60	0.902
61	0.899
62	0.899
63	0.9
64	0.899
65	0.9
66	0.899
67	0.898
68	0.896
69	0.897
70	0.899
71	0.899
72	0.9
73	0.9
74	0.901
75	0.9

76	0.899
77	0.897
78	0.897
79	0.9
80	0.899
81	0.897
82	0.897
83	0.897
84	0.895
85	0.897
86	0.898
87	0.896
88	0.894
89	0.896
90	0.897
91	0.895
92	0.897
93	0.897
94	0.896
95	0.896
96	0.896
97	0.896
98	0.896
99	0.896