Benchmark Results for VeriNet

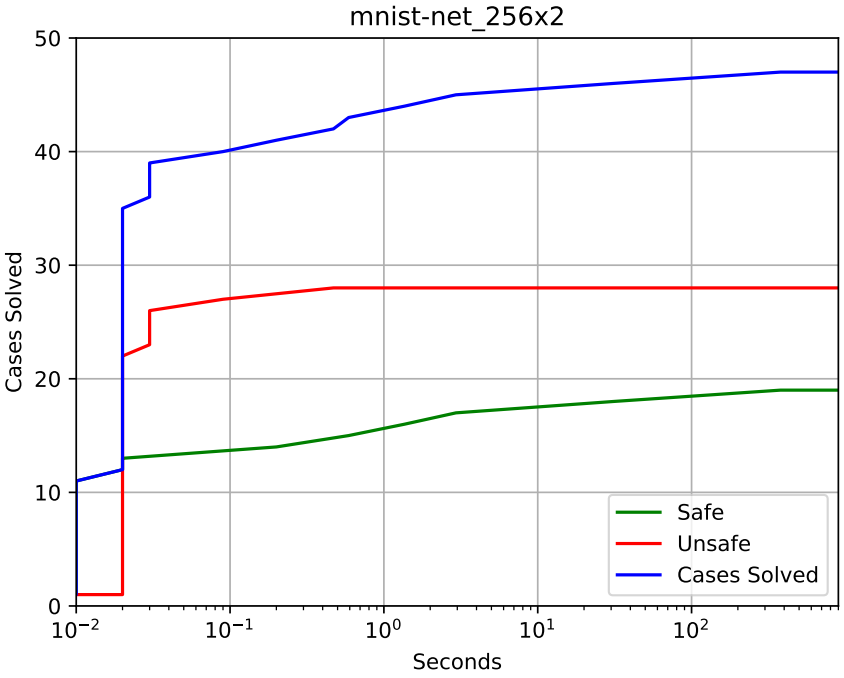
July 18, 2020

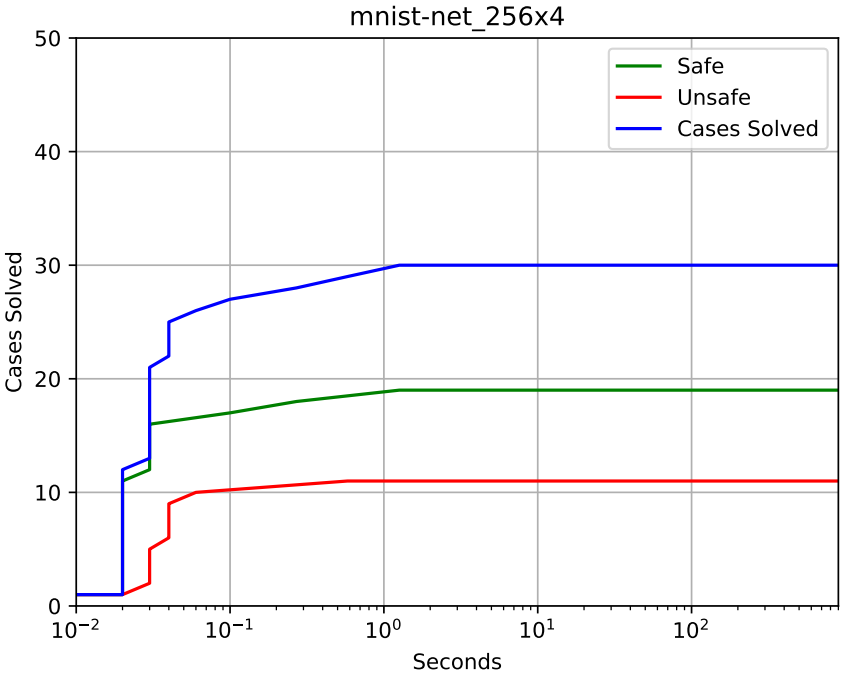
1 About

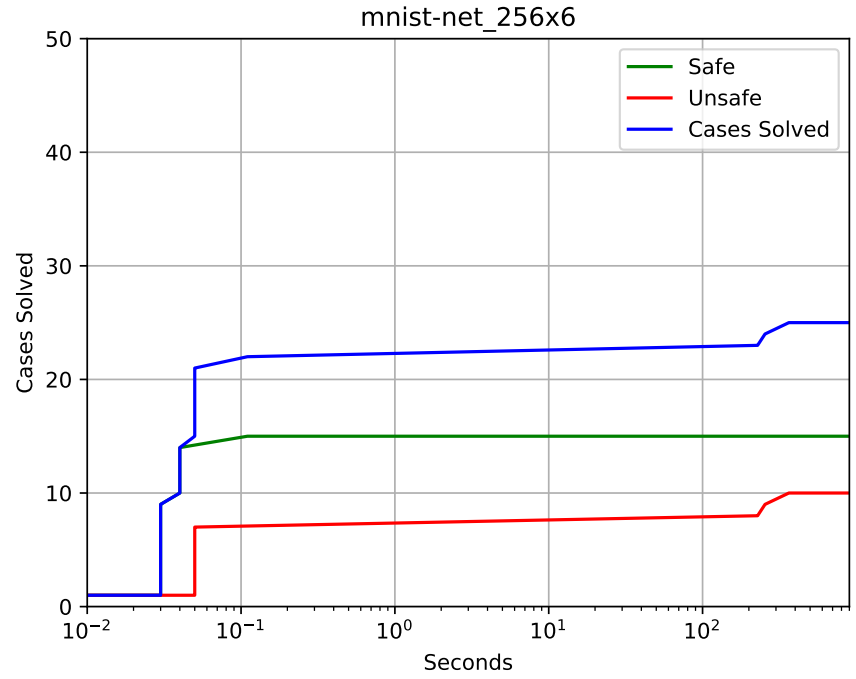
VeriNet [1] is a symbolic-interval propagation-based toolkit for local robustness properties supporting ReLU, Sigmoid and Tanh activation functions and Fully-Connected, Convolutional and Batch-normalisation layers. VeriNet uses several novels techniques to achieve a high level of performance, include a local gradient-based search around spurious counterexamples, an adaptive refinement strategy and optimal relaxations for the Sigmoid and Tanh activation functions.

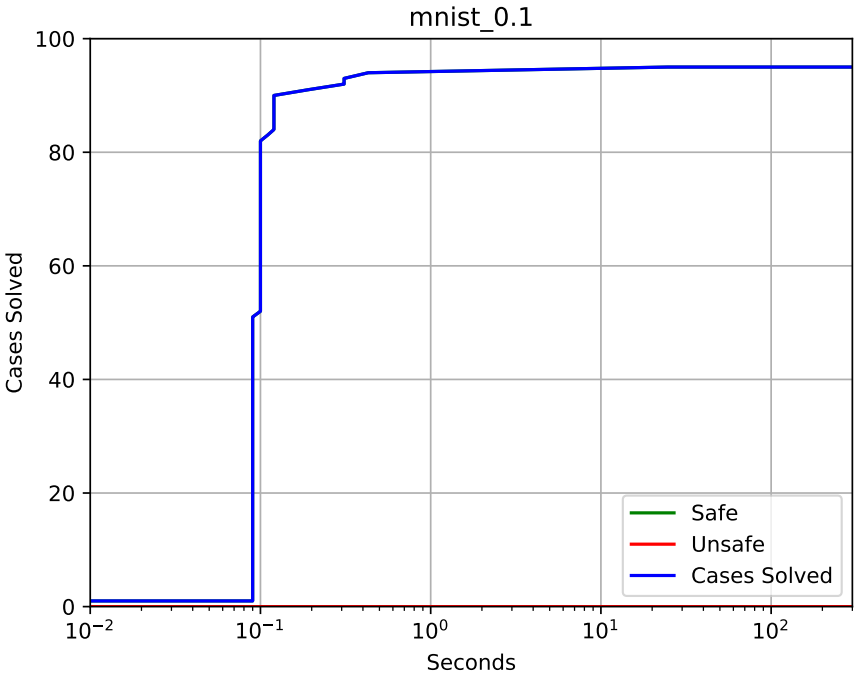
We ran our toolkit on benchmarks in all three categories; however, we did not evaluate the ACAS Xu Benchmarks as VeriNet does not support all of the properties at this point. We Also did not evaluate VeriNet on all of the Cifar10 convolutional networks due to time constraints. We ran all benchmarks on a workstation with a Ryzen 3700X 3.6 GHz 8-core CPU, 64 GB ram running Ubuntu 20.04 LTS with Linux kernel 5.4.0. The VeriNet code is available at `https://vas.doc.ic.ac.uk/software/neural/`

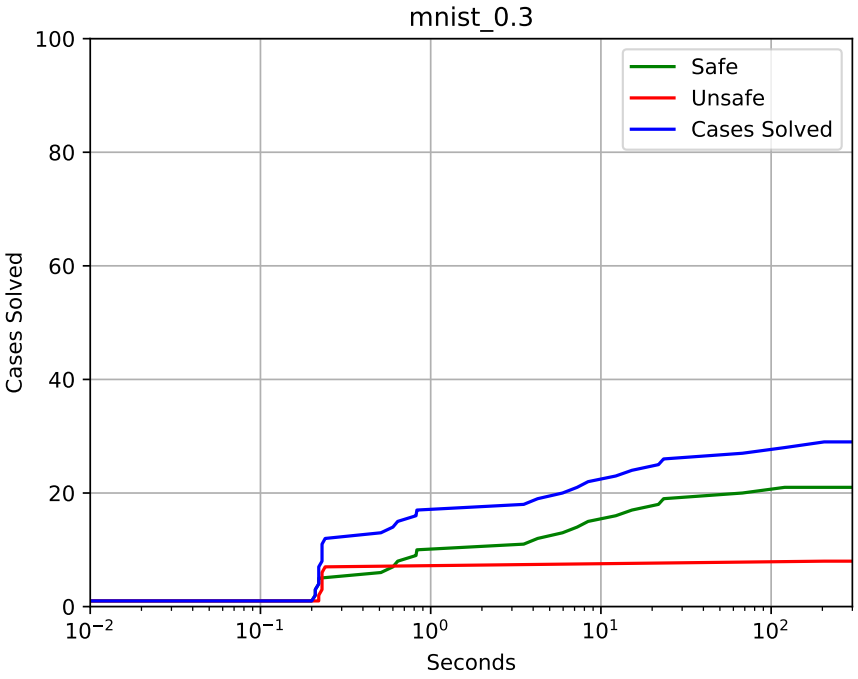
2 Results

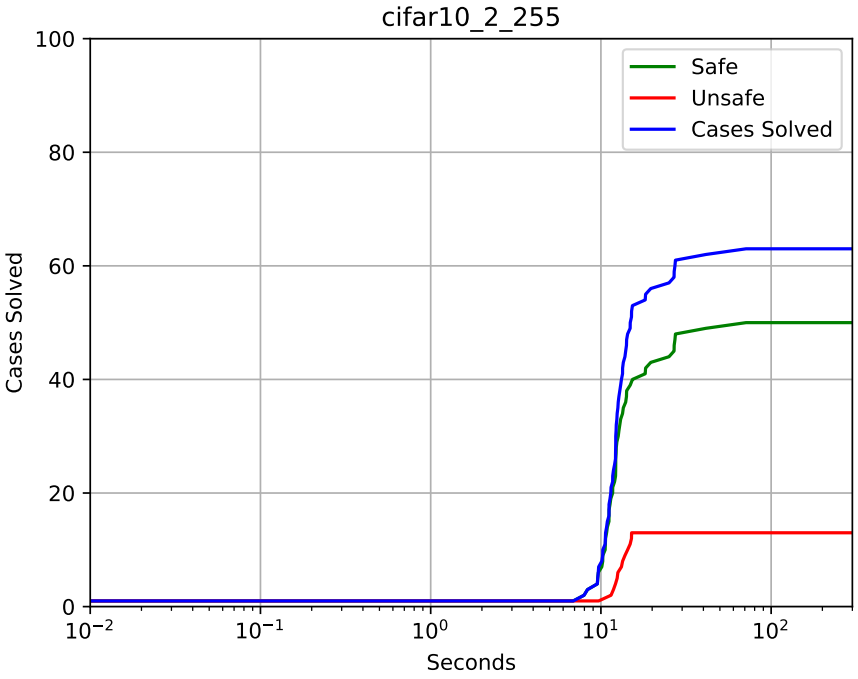

mnist-net_256x2
Cases Solved
Seconds
Safe
Unsafe
Cases Solved
0
10
20
30
40
50
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}

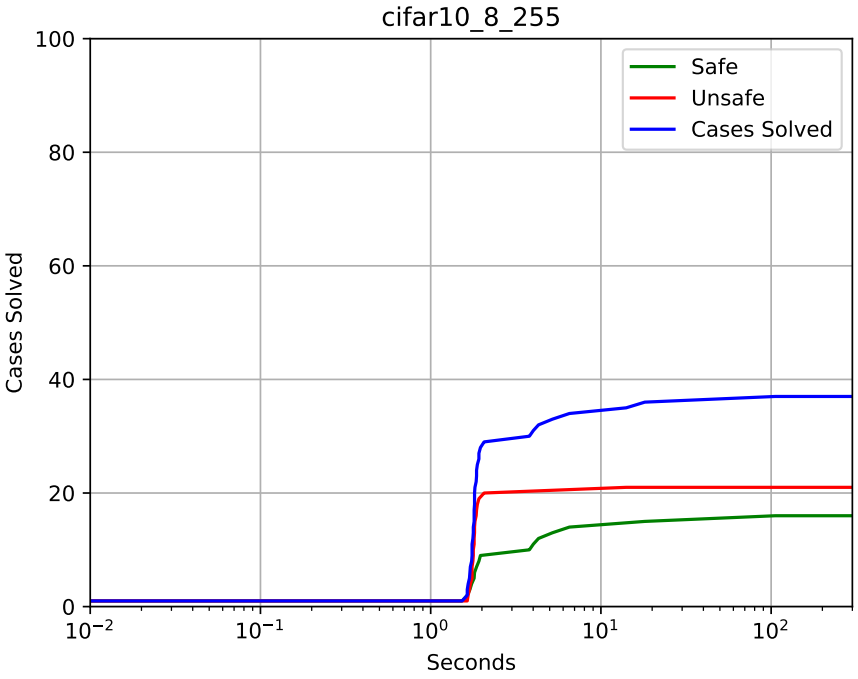

mnist-net_256x4
Cases Solved
Seconds
Safe
Unsafe
Cases Solved
0
10
20
30
40
50
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}

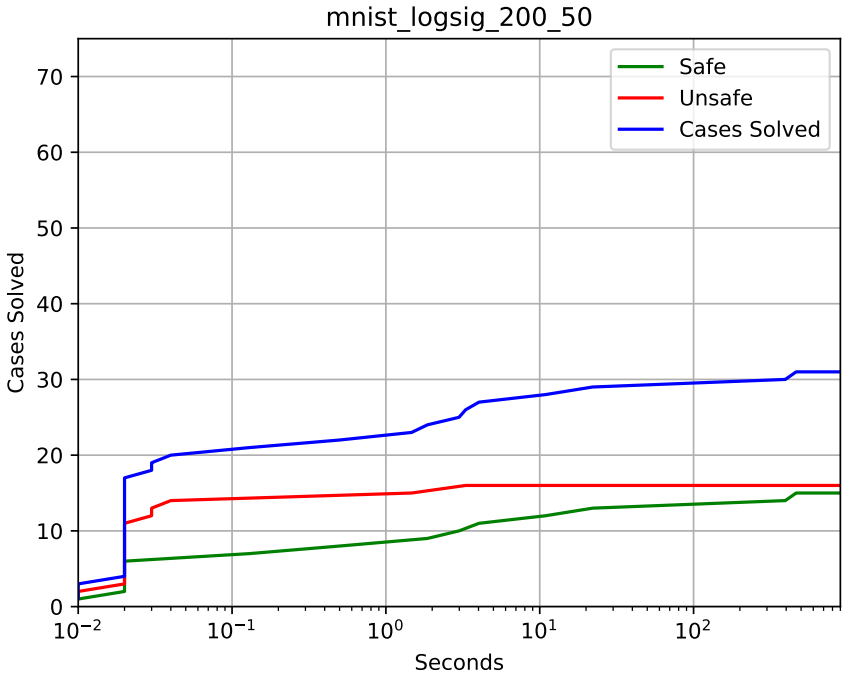

mnist-net_256x6
Safe
Unsafe
Cases Solved
Cases Solved
Seconds
0
10
20
30
40
50
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}

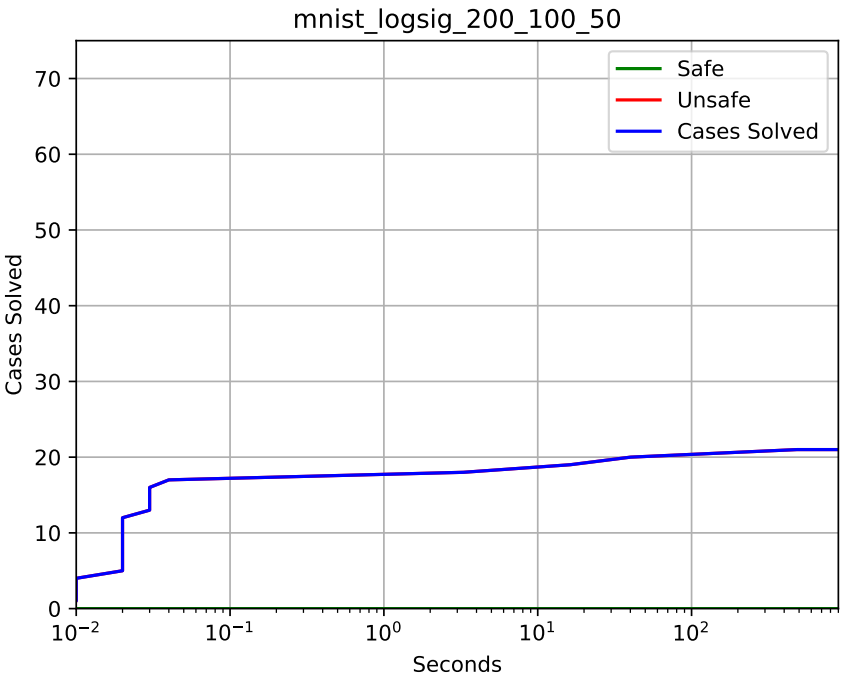

mnist_0.1
Safe
Unsafe
Cases Solved
Cases Solved
Seconds
0
20
40
60
80
100
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}

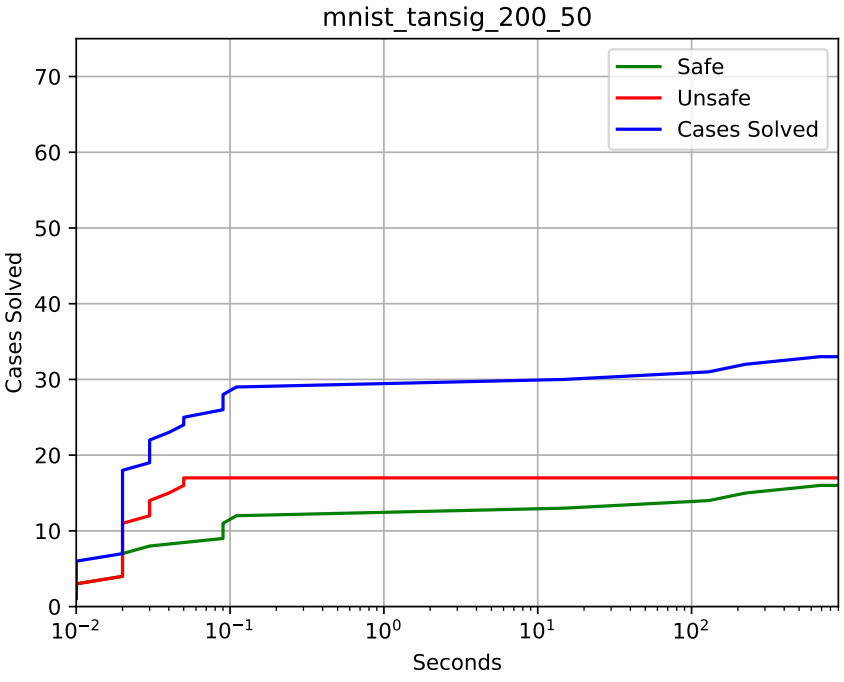

mnist_0.3
Safe
Unsafe
Cases Solved
Cases Solved
Seconds
0
20
40
60
80
100
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}


cifar10_2_255
Safe
Unsafe
Cases Solved
Cases Solved
Seconds
0
20
40
60
80
100
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}


cifar10_8_255
Safe
Unsafe
Cases Solved
Cases Solved
Seconds
0
20
40
60
80
100
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}


mnist_logsig_200_50
Safe
Unsafe
Cases Solved
Cases Solved
Seconds
0
10
20
30
40
50
60
70
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}


mnist_logsig_200_100_50
Safe
Unsafe
Cases Solved
Cases Solved
Seconds
0
10
20
30
40
50
60
70
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}


mnist_tansig_200_50
Safe
Unsafe
Cases Solved
Cases Solved
Seconds
0
10
20
30
40
50
60
70
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}

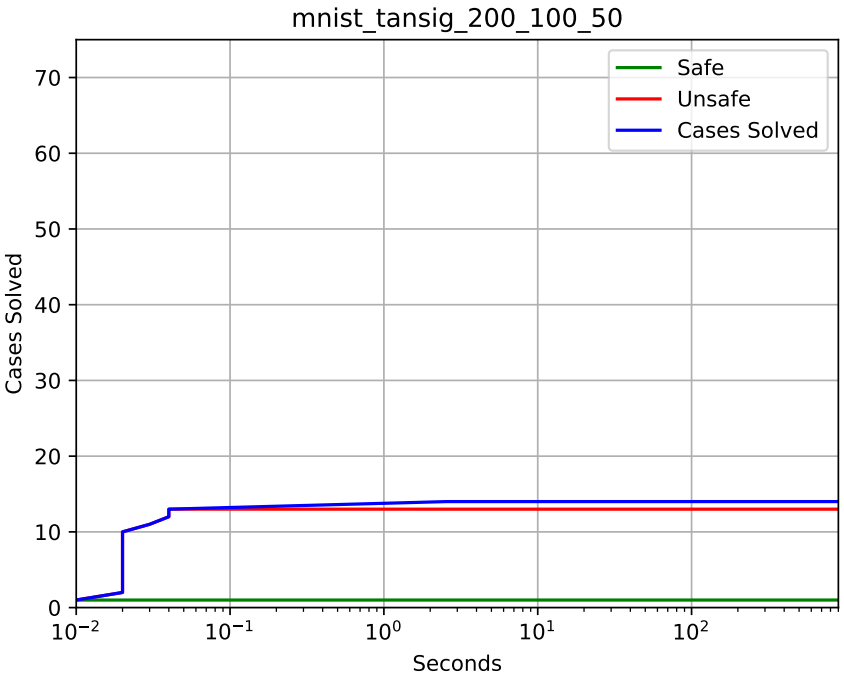

mnist_tansig_200_100_50
Safe
Unsafe
Cases Solved
Cases Solved
Seconds
0
10
20
30
40
50
60
70
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}

Table 1: mnist-net 256x2

Epsilon: 0.020			Epsilon: 0.050		
Image	Status	Time(s)	Image	Status	Time(s)
0	Unsafe	0.09	0	Unsafe	0.02
1	Safe	0.01	1	Unsafe	0.02
2	Unsafe	0.02	2	Unsafe	0.02
3	Safe	0.01	3	Unsafe	0.02
4	Unsafe	0.02	4	Unsafe	0.02
5	Safe	0.2	5	Unsafe	0.02
6	Safe	378.33	6	Unsafe	0.02
7	Safe	2.94	7	Unsafe	0.02
8	Unsafe	0.02	8	Unsafe	0.02
9	Safe	0.01	9	Unsafe	0.02
10	Safe	0.01	10	Undecided	900.0
11	Safe	0.01	11	Unsafe	0.03
12	Safe	0.01	12	Unsafe	0.02
13	Safe	0.01	13	Unsafe	0.02
14	Safe	0.01	14	Unsafe	0.47
15	Safe	0.01	15	Undecided	900.0
16	Safe	0.01	16	Unsafe	0.03
17	Safe	30.92	17	Unsafe	0.02
18	Unsafe	0.03	18	Unsafe	0.02
19	Safe	0.59	19	Unsafe	0.02
20	Safe	0.02	20	Unsafe	0.02
21	Safe	1.36	21	Unsafe	0.02
22	Safe	0.02	22	Undecided	900.0
23	Safe	0.01	23	Unsafe	0.03
24	Unsafe	0.02	24	Unsafe	0.02

Table 2: mnist-net 256x4

Epsilon: 0.020			Epsilon: 0.050		
Image	Status	Time(s)	Image	Status	Time(s)
0	Safe	0.1	0	Undecided	900.0
1	Safe	0.02	1	Undecided	900.0
2	Undecided	900.0	2	Unsafe	0.58
3	Safe	0.03	3	Undecided	900.0
4	Safe	0.02	4	Undecided	900.0
5	Safe	0.27	5	Undecided	900.0
6	Safe	0.03	6	Unsafe	0.04
7	Undecided	900.0	7	Unsafe	0.03
8	Safe	1.26	8	Unsafe	0.03
9	Safe	0.03	9	Undecided	900.0
10	Safe	0.02	10	Undecided	900.0
11	Safe	0.02	11	Undecided	900.0
12	Safe	0.02	12	Undecided	900.0
13	Safe	0.02	13	Undecided	900.0
14	Safe	0.02	14	Unsafe	0.04
15	Safe	0.02	15	Undecided	900.0
16	Undecided	900.0	16	Unsafe	0.06
17	Safe	0.03	17	Undecided	900.0
18	Unsafe	0.02	18	Unsafe	0.04
19	Safe	0.02	19	Unsafe	0.03
20	Undecided	900.0	20	Unsafe	0.03
21	Safe	0.03	21	Undecided	900.0
22	Safe	0.02	22	Undecided	900.0
23	Safe	0.02	23	Undecided	900.0
24	Undecided	900.0	24	Unsafe	0.04

Table 3: mnist-net 256x6

Epsilon: 0.020			Epsilon: 0.050		
Image	Status	Time(s)	Image	Status	Time(s)
0	Safe	0.11	0	Unsafe	363.99
1	Safe	0.03	1	Undecided	900.0
2	Undecided	900.0	2	Unsafe	0.05
3	Safe	0.04	3	Undecided	900.0
4	Safe	0.03	4	Undecided	900.0
5	Undecided	900.0	5	Undecided	900.0
6	Undecided	900.0	6	Unsafe	0.05
7	Undecided	900.0	7	Unsafe	254.71
8	Unsafe	0.05	8	Unsafe	0.05
9	Safe	0.03	9	Undecided	900.0
10	Safe	0.03	10	Undecided	900.0
11	Safe	0.03	11	Unsafe	0.05
12	Undecided	900.0	12	Undecided	900.0
13	Safe	0.04	13	Undecided	900.0
14	Safe	0.03	14	Undecided	900.0
15	Safe	0.03	15	Undecided	900.0
16	Undecided	900.0	16	Unsafe	227.87
17	Safe	0.04	17	Undecided	900.0
18	Undecided	900.0	18	Unsafe	0.05
19	Safe	0.04	19	Undecided	900.0
20	Undecided	900.0	20	Undecided	900.0
21	Safe	0.04	21	Undecided	900.0
22	Safe	0.03	22	Undecided	900.0
23	Safe	0.03	23	Undecided	900.0
24	Undecided	900.0	24	Unsafe	0.05

Table 4: mnist 0.1

Epsilon: 0.100			Epsilon: 0.100		
Image	Status	Time(s)	Image	Status	Time(s)
0	Safe	0.19	50	Safe	0.1
1	Safe	0.1	51	Safe	0.09
2	Safe	0.1	52	Safe	0.1
3	Safe	0.1	53	Safe	0.09
4	Safe	0.1	54	Safe	0.1
5	Safe	0.09	55	Safe	0.1
6	Undecided	300.0	56	Safe	0.09
7	Safe	0.12	57	Safe	0.1
8	Undecided	300.0	58	Safe	0.1
9	Safe	0.12	59	Safe	0.43
10	Safe	0.09	60	Safe	0.12
11	Safe	0.09	61	Safe	0.09
12	Safe	0.09	62	Undecided	300.0
13	Safe	0.09	63	Safe	0.12
14	Safe	0.09	64	Safe	0.1
15	Safe	0.09	65	Safe	24.58
16	Safe	0.09	66	Safe	0.12
17	Safe	0.09	67	Safe	0.09
18	Undecided	300.0	68	Safe	0.1
19	Safe	0.12	69	Safe	0.09
20	Safe	0.09	70	Safe	0.1
21	Safe	0.09	71	Safe	0.09
22	Safe	0.09	72	Safe	0.1
23	Safe	0.1	73	Safe	0.09
24	Safe	0.1	74	Safe	0.09
25	Safe	0.09	75	Safe	0.09
26	Safe	0.09	76	Safe	0.09
27	Safe	0.09	77	Safe	0.09
28	Safe	0.09	78	Safe	0.1
29	Safe	0.09	79	Safe	0.09
30	Safe	0.09	80	Safe	0.1
31	Safe	0.09	81	Safe	0.09
32	Safe	0.09	82	Safe	0.09
33	Safe	0.1	83	Safe	0.09
34	Safe	0.09	84	Safe	0.1
35	Safe	0.1	85	Safe	0.1
36	Safe	0.09	86	Safe	0.1
37	Safe	0.09	87	Safe	0.09
38	Safe	0.1	88	Safe	0.1
39	Safe	0.09	89	Safe	0.09
40	Safe	0.1	90	Safe	0.1
41	Safe	0.09	91	Safe	0.09
42	Safe	0.09	92	Undecided	300.0
43	Safe	0.09	93	Safe	0.31
44	Safe	0.09	94	Safe	0.11
45	Safe	0.09	95	Safe	0.31
46	Safe	0.09	96	Safe	0.12
47	Safe	0.1	97	Safe	0.09
48	Safe	0.1	98	Safe	0.1
49	Safe	0.1	99	Safe	0.09

Table 5: mnist 0.3

Epsilon: 0.300			Epsilon: 0.300		
Image	Status	Time(s)	Image	Status	Time(s)
0	Safe	12.23	50	Undecided	300.0
1	Undecided	300.0	51	Undecided	300.0
2	Undecided	300.0	52	Undecided	300.0
3	Undecided	300.0	53	Undecided	300.0
4	Undecided	300.0	54	Undecided	300.0
5	Safe	21.79	55	Safe	15.22
6	Undecided	300.0	56	Undecided	300.0
7	Undecided	300.0	57	Undecided	300.0
8	Unsafe	0.22	58	Undecided	300.0
9	Undecided	300.0	59	Undecided	300.0
10	Safe	23.35	60	Safe	0.22
11	Undecided	300.0	61	Undecided	300.0
12	Undecided	300.0	62	Unsafe	204.86
13	Undecided	300.0	63	Unsafe	0.23
14	Safe	0.2	64	Undecided	300.0
15	Undecided	300.0	65	Misclassified	0.0
16	Undecided	300.0	66	Undecided	300.0
17	Safe	5.95	67	Undecided	300.0
18	Unsafe	0.24	68	Undecided	300.0
19	Undecided	300.0	69	Undecided	300.0
20	Undecided	300.0	70	Safe	0.22
21	Undecided	300.0	71	Safe	7.25
22	Undecided	300.0	72	Undecided	300.0
23	Undecided	300.0	73	Unsafe	0.22
24	Undecided	300.0	74	Safe	0.6
25	Safe	8.41	75	Undecided	300.0
26	Undecided	300.0	76	Undecided	300.0
27	Undecided	300.0	77	Undecided	300.0
28	Undecided	300.0	78	Undecided	300.0
29	Undecided	300.0	79	Safe	0.83
30	Undecided	300.0	80	Undecided	300.0
31	Undecided	300.0	81	Undecided	300.0
32	Safe	4.25	82	Safe	0.82
33	Unsafe	0.23	83	Safe	120.14
34	Undecided	300.0	84	Undecided	300.0
35	Undecided	300.0	85	Safe	3.52
36	Undecided	300.0	86	Undecided	300.0
37	Safe	0.21	87	Undecided	300.0
38	Undecided	300.0	88	Undecided	300.0
39	Safe	0.21	89	Undecided	300.0
40	Safe	0.51	90	Undecided	300.0
41	Undecided	300.0	91	Undecided	300.0
42	Undecided	300.0	92	Unsafe	0.23
43	Unsafe	0.23	93	Undecided	300.0
44	Undecided	300.0	94	Safe	67.79
45	Undecided	300.0	95	Undecided	300.0
46	Safe	0.64	96	Undecided	300.0
47	Undecided	300.0	97	Undecided	300.0
48	Undecided	300.0	98	Undecided	300.0
49	Undecided	300.0	99	Undecided	300.0

Table 6: cifar10 2 255

Epsilon: 0.008			Epsilon: 0.008		
Image	Status	Time(s)	Image	Status	Time(s)
0	Unsafe	9.7	50	Undecided	300.0
1	Safe	7.96	51	Undecided	300.0
2	Undecided	300.0	52	Misclassified	0.0
3	Safe	18.21	53	Undecided	300.0
4	Undecided	300.0	54	Safe	10.8
5	Safe	71.23	55	Safe	10.65
6	Safe	19.63	56	Misclassified	0.0
7	Misclassified	0.0	57	Misclassified	0.0
8	Undecided	300.0	58	Misclassified	0.0
9	Undecided	300.0	59	Misclassified	0.0
10	Safe	15.32	60	Safe	13.06
11	Safe	9.65	61	Misclassified	0.0
12	Unsafe	13.84	62	Safe	11.31
13	Safe	12.19	63	Misclassified	0.0
14	Safe	13.4	64	Undecided	300.0
15	Safe	12.28	65	Unsafe	13.41
16	Undecided	300.0	66	Undecided	300.0
17	Safe	13.54	67	Safe	10.12
18	Safe	11.43	68	Undecided	300.0
19	Safe	14.13	69	Misclassified	0.0
20	Safe	25.12	70	Misclassified	0.0
21	Safe	6.88	71	Undecided	300.0
22	Misclassified	0.0	72	Safe	9.58
23	Safe	12.76	73	Safe	12.03
24	Misclassified	0.0	74	Unsafe	12.18
25	Undecided	300.0	75	Safe	11.16
26	Unsafe	15.14	76	Unsafe	12.46
27	Undecided	300.0	77	Undecided	300.0
28	Unsafe	12.58	78	Safe	27.22
29	Safe	14.16	79	Safe	9.53
30	Undecided	300.0	80	Safe	11.73
31	Unsafe	14.35	81	Safe	10.26
32	Unsafe	14.85	82	Safe	12.22
33	Undecided	300.0	83	Safe	10.25
34	Safe	12.41	84	Safe	10.59
35	Misclassified	0.0	85	Misclassified	0.0
36	Unsafe	15.12	86	Unsafe	11.85
37	Unsafe	11.47	87	Misclassified	0.0
38	Safe	12.91	88	Safe	11.72
39	Safe	41.37	89	Safe	12.22
40	Safe	12.64	90	Safe	11.15
41	Safe	12.31	91	Misclassified	0.0
42	Undecided	300.0	92	Safe	10.91
43	Safe	14.87	93	Safe	26.9
44	Safe	10.62	94	Safe	26.94
45	Safe	11.16	95	Unsafe	13.2
46	Safe	27.41	96	Safe	13.98
47	Misclassified	0.0	97	Safe	18.3
48	Undecided	300.0	98	Safe	8.34
49	Misclassified	0.0	99	Safe	12.21

Table 7: cifar10 8 255

Epsilon: 0.031			Epsilon: 0.031		
Image	Status	Time(s)	Image	Status	Time(s)
0	Misclassified	0.0	50	Safe	1.96
1	Safe	6.53	51	Undecided	300.0
2	Undecided	300.0	52	Misclassified	0.0
3	Misclassified	0.0	53	Misclassified	0.0
4	Unsafe	1.85	54	Safe	4.01
5	Undecided	300.0	55	Safe	105.64
6	Misclassified	0.0	56	Misclassified	0.0
7	Misclassified	0.0	57	Misclassified	0.0
8	Misclassified	0.0	58	Misclassified	0.0
9	Unsafe	1.77	59	Misclassified	0.0
10	Undecided	300.0	60	Unsafe	1.81
11	Undecided	300.0	61	Misclassified	0.0
12	Misclassified	0.0	62	Misclassified	0.0
13	Safe	5.19	63	Misclassified	0.0
14	Undecided	300.0	64	Undecided	300.0
15	Undecided	300.0	65	Misclassified	0.0
16	Safe	1.8	66	Undecided	300.0
17	Misclassified	0.0	67	Unsafe	1.78
18	Safe	1.74	68	Misclassified	0.0
19	Unsafe	1.88	69	Misclassified	0.0
20	Misclassified	0.0	70	Misclassified	0.0
21	Safe	1.53	71	Undecided	300.0
22	Misclassified	0.0	72	Undecided	300.0
23	Unsafe	1.81	73	Undecided	300.0
24	Misclassified	0.0	74	Unsafe	1.92
25	Misclassified	0.0	75	Misclassified	0.0
26	Misclassified	0.0	76	Undecided	300.0
27	Misclassified	0.0	77	Misclassified	0.0
28	Undecided	300.0	78	Misclassified	0.0
29	Safe	3.8	79	Unsafe	1.64
30	Unsafe	2.06	80	Undecided	300.0
31	Misclassified	0.0	81	Safe	1.86
32	Unsafe	1.75	82	Safe	1.81
33	Unsafe	1.8	83	Unsafe	1.66
34	Safe	4.3	84	Undecided	300.0
35	Misclassified	0.0	85	Misclassified	0.0
36	Misclassified	0.0	86	Unsafe	1.86
37	Misclassified	0.0	87	Misclassified	0.0
38	Unsafe	1.82	88	Undecided	300.0
39	Unsafe	1.78	89	Unsafe	1.8
40	Misclassified	0.0	90	Unsafe	1.75
41	Safe	1.92	91	Misclassified	0.0
42	Misclassified	0.0	92	Safe	1.7
43	Misclassified	0.0	93	Misclassified	0.0
44	Unsafe	1.69	94	Misclassified	0.0
45	Undecided	300.0	95	Unsafe	1.75
46	Misclassified	0.0	96	Unsafe	14.08
47	Misclassified	0.0	97	Undecided	300.0
48	Misclassified	0.0	98	Safe	1.64
49	Safe	18.1	99	Unsafe	1.71

Table 8: mnist logsig 200 50

Epsilon: 3.000			Epsilon: 5.000			Epsilon: 12.000		
Image	Status	Time(s)	Image	Status	Time(s)	Image	Status	Time(s)
0	Safe	0.13	0	Undecided	900.0	0	Undecided	900.0
1	Safe	4.03	1	Undecided	900.0	1	Undecided	900.0
2	Undecided	900.0	2	Undecided	900.0	2	Unsafe	0.03
3	Safe	0.02	3	Safe	464.32	3	Undecided	900.0
4	Safe	22.06	4	Undecided	900.0	4	Unsafe	0.03
5	Safe	0.02	5	Undecided	900.0	5	Undecided	900.0
6	Undecided	900.0	6	Undecided	900.0	6	Unsafe	0.02
7	Undecided	900.0	7	Undecided	900.0	7	Undecided	900.0
8	Unsafe	0.02	8	Unsafe	0.02	8	Unsafe	0.02
9	Safe	2.99	9	Undecided	900.0	9	Unsafe	0.01
10	Safe	0.02	10	Undecided	900.0	10	Undecided	900.0
11	Undecided	900.0	11	Undecided	900.0	11	Unsafe	0.04
12	Safe	10.91	12	Undecided	900.0	12	Undecided	900.0
13	Safe	0.02	13	Undecided	900.0	13	Undecided	900.0
14	Safe	0.01	14	Undecided	900.0	14	Undecided	900.0
15	Undecided	900.0	15	Undecided	900.0	15	Unsafe	0.02
16	Undecided	900.0	16	Undecided	900.0	16	Unsafe	3.3
17	Safe	0.02	17	Undecided	900.0	17	Undecided	900.0
18	Unsafe	0.01	18	Unsafe	0.02	18	Unsafe	0.02
19	Safe	0.5	19	Undecided	900.0	19	Undecided	900.0
20	Safe	1.86	20	Undecided	900.0	20	Unsafe	0.02
21	Undecided	900.0	21	Undecided	900.0	21	Unsafe	1.47
22	Safe	394.82	22	Undecided	900.0	22	Undecided	900.0
23	Undecided	900.0	23	Undecided	900.0	23	Undecided	900.0
24	Undecided	900.0	24	Undecided	900.0	24	Unsafe	0.02

Table 9: mnist logsig 200 100 50

Epsilon: 3.000			Epsilon: 5.000			Epsilon: 12.000		
Image	Status	Time(s)	Image	Status	Time(s)	Image	Status	Time(s)
0	Undecided	900.0	0	Undecided	900.0	0	Undecided	900.0
1	Undecided	900.0	1	Undecided	900.0	1	Undecided	900.0
2	Undecided	900.0	2	Undecided	900.0	2	Unsafe	0.03
3	Undecided	900.0	3	Undecided	900.0	3	Undecided	900.0
4	Undecided	900.0	4	Undecided	900.0	4	Unsafe	0.02
5	Undecided	900.0	5	Undecided	900.0	5	Unsafe	0.02
6	Undecided	900.0	6	Undecided	900.0	6	Unsafe	0.01
7	Undecided	900.0	7	Undecided	900.0	7	Unsafe	0.02
8	Unsafe	3.29	8	Unsafe	0.03	8	Unsafe	0.01
9	Undecided	900.0	9	Undecided	900.0	9	Unsafe	484.32
10	Undecided	900.0	10	Undecided	900.0	10	Unsafe	16.27
11	Undecided	900.0	11	Undecided	900.0	11	Unsafe	0.03
12	Undecided	900.0	12	Undecided	900.0	12	Unsafe	0.01
13	Undecided	900.0	13	Undecided	900.0	13	Undecided	900.0
14	Undecided	900.0	14	Undecided	900.0	14	Undecided	900.0
15	Undecided	900.0	15	Undecided	900.0	15	Unsafe	0.03
16	Undecided	900.0	16	Undecided	900.0	16	Unsafe	40.09
17	Undecided	900.0	17	Undecided	900.0	17	Undecided	900.0
18	Unsafe	0.02	18	Unsafe	0.02	18	Unsafe	0.02
19	Undecided	900.0	19	Undecided	900.0	19	Unsafe	0.02
20	Undecided	900.0	20	Unsafe	0.04	20	Unsafe	0.01
21	Undecided	900.0	21	Undecided	900.0	21	Undecided	900.0
22	Undecided	900.0	22	Undecided	900.0	22	Undecided	900.0
23	Undecided	900.0	23	Undecided	900.0	23	Undecided	900.0
24	Undecided	900.0	24	Undecided	900.0	24	Unsafe	0.02

Table 10: mnist tansig 200 50

Epsilon: 3.000			Epsilon: 5.000			Epsilon: 12.000		
Image	Status	Time(s)	Image	Status	Time(s)	Image	Status	Time(s)
0	Safe	0.09	0	Undecided	900.0	0	Undecided	900.0
1	Safe	0.01	1	Undecided	900.0	1	Undecided	900.0
2	Undecided	900.0	2	Undecided	900.0	2	Unsafe	0.02
3	Safe	0.11	3	Undecided	900.0	3	Undecided	900.0
4	Undecided	900.0	4	Undecided	900.0	4	Unsafe	0.03
5	Undecided	900.0	5	Undecided	900.0	5	Unsafe	0.04
6	Safe	224.27	6	Undecided	900.0	6	Unsafe	0.02
7	Safe	0.02	7	Undecided	900.0	7	Undecided	900.0
8	Unsafe	0.01	8	Unsafe	0.02	8	Unsafe	0.02
9	Safe	683.25	9	Undecided	900.0	9	Unsafe	0.05
10	Safe	14.84	10	Undecided	900.0	10	Unsafe	0.01
11	Safe	0.09	11	Undecided	900.0	11	Unsafe	0.03
12	Safe	0.02	12	Undecided	900.0	12	Undecided	900.0
13	Safe	0.01	13	Undecided	900.0	13	Undecided	900.0
14	Safe	0.09	14	Undecided	900.0	14	Undecided	900.0
15	Undecided	900.0	15	Unsafe	0.02	15	Unsafe	0.02
16	Safe	129.39	16	Undecided	900.0	16	Undecided	900.0
17	Safe	0.02	17	Undecided	900.0	17	Undecided	900.0
18	Undecided	900.0	18	Unsafe	0.02	18	Unsafe	0.02
19	Safe	0.02	19	Undecided	900.0	19	Undecided	900.0
20	Undecided	900.0	20	Undecided	900.0	20	Unsafe	0.05
21	Undecided	900.0	21	Undecided	900.0	21	Unsafe	0.01
22	Safe	0.03	22	Undecided	900.0	22	Undecided	900.0
23	Safe	0.01	23	Undecided	900.0	23	Undecided	900.0
24	Undecided	900.0	24	Undecided	900.0	24	Unsafe	0.03

Table 11: mnist tansig 200 100 50

Epsilon: 3.000			Epsilon: 5.000			Epsilon: 12.000		
Image	Status	Time(s)	Image	Status	Time(s)	Image	Status	Time(s)
0	Undecided	900.0	0	Undecided	900.0	0	Undecided	900.0
1	Undecided	900.0	1	Undecided	900.0	1	Undecided	900.0
2	Undecided	900.0	2	Undecided	900.0	2	Unsafe	0.02
3	Undecided	900.0	3	Undecided	900.0	3	Undecided	900.0
4	Undecided	900.0	4	Undecided	900.0	4	Unsafe	0.04
5	Undecided	900.0	5	Undecided	900.0	5	Unsafe	0.02
6	Undecided	900.0	6	Undecided	900.0	6	Unsafe	0.02
7	Undecided	900.0	7	Undecided	900.0	7	Unsafe	0.02
8	Unsafe	0.02	8	Unsafe	0.02	8	Unsafe	0.01
9	Undecided	900.0	9	Undecided	900.0	9	Unsafe	0.04
10	Undecided	900.0	10	Undecided	900.0	10	Undecided	900.0
11	Undecided	900.0	11	Undecided	900.0	11	Undecided	900.0
12	Undecided	900.0	12	Undecided	900.0	12	Undecided	900.0
13	Safe	2.55	13	Undecided	900.0	13	Undecided	900.0
14	Undecided	900.0	14	Undecided	900.0	14	Undecided	900.0
15	Undecided	900.0	15	Undecided	900.0	15	Unsafe	0.02
16	Undecided	900.0	16	Undecided	900.0	16	Undecided	900.0
17	Undecided	900.0	17	Undecided	900.0	17	Undecided	900.0
18	Undecided	900.0	18	Undecided	900.0	18	Unsafe	0.02
19	Undecided	900.0	19	Undecided	900.0	19	Undecided	900.0
20	Undecided	900.0	20	Undecided	900.0	20	Undecided	900.0
21	Undecided	900.0	21	Undecided	900.0	21	Unsafe	0.03
22	Undecided	900.0	22	Undecided	900.0	22	Undecided	900.0
23	Undecided	900.0	23	Undecided	900.0	23	Undecided	900.0
24	Undecided	900.0	24	Undecided	900.0	24	Unsafe	0.02

References

[1] P. Henriksen and A. Lomuscio. Efficient neural network verification via adaptive refinement and adversarial search. In *Proceedings of the 24th European Conference on Artificial Intelligence (ECAI20)*, 2020.