Lab report 2 (variant 13)

Task

Develop MLP with one hidden layer using any programming language for prediction of the following function:

$$y = \alpha \sin(bx) + d$$

α	b	d	number of inputs
4	2	0,5	3

Chosen values: α=0.22; E_m=0.0001.

Learning outcomes

1. **Training 30 points.**

	y
1	1,294677
2	2,057673
3	2,75857
4	3,369424
5	3,865884
6	4,228156
7	4,441799
8	4,498294
9	4,395391
10	4,13719
11	3,733986
12	3,201853
13	2,562005
14	1,839953
15	1,06448
16	0,266503
17	-0,522164
18	-1,270082
19	-1,947432
20	-2,52721
21	-2,986303
22	-3,306408
23	-3,474764
24	-3,484658
25	-3,335697
26	-3,033819
27	-2,591058
28	-2,025067

29	-1,358409
30	-0,617662
31	0,167642
32	0,966197
33	1,746165
34	2,476453
35	3,127946
36	3,674671
37	4,094832
38	4,371679
39	4,494173
40	4,457433
41	4,262922
42	3,918396
43	3,437588
44	2,839669
45	2,148474
46	1,39156
47	0,599102
48	-0,197307
49	-0,965917
50	-1,676084

Tab1. Theoretical and training outputs

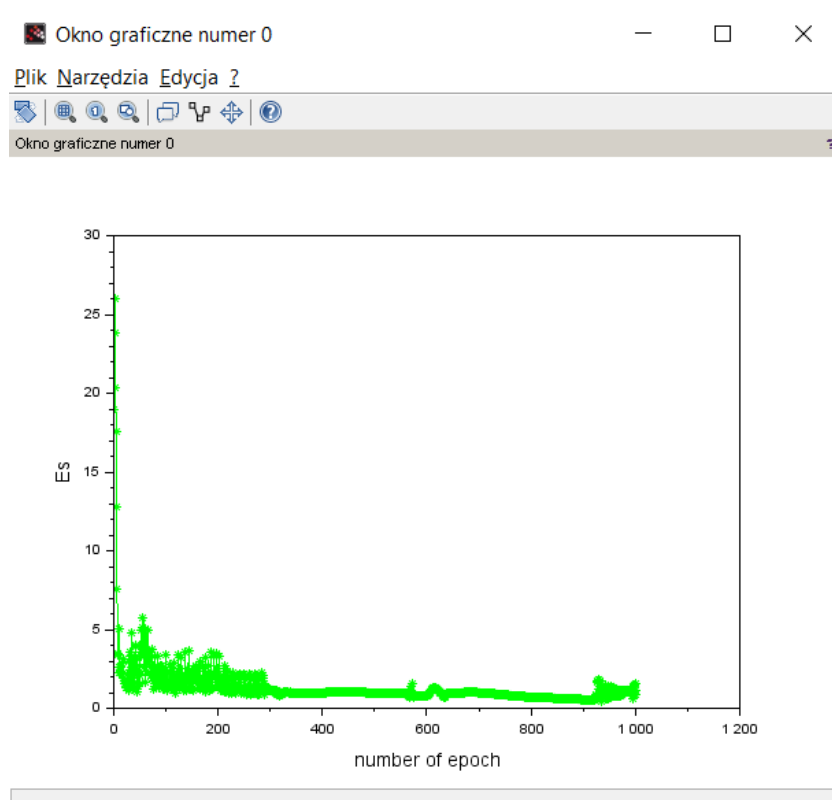|	
w(11)	0,070503
w(12)	0,034894
w(13)	0,083057
v(1)	-0,0943
w(21)	-0,05264
w(22)	0,040307
w(23)	-0,07595
v(2)	0,065748
w(31)	-0,03678
w(32)	0,006104
w(33)	0,014303
v(3)	-0,09044

Tab2. The weights of input and hidden neurons

Initial thresholds are taken as 0.
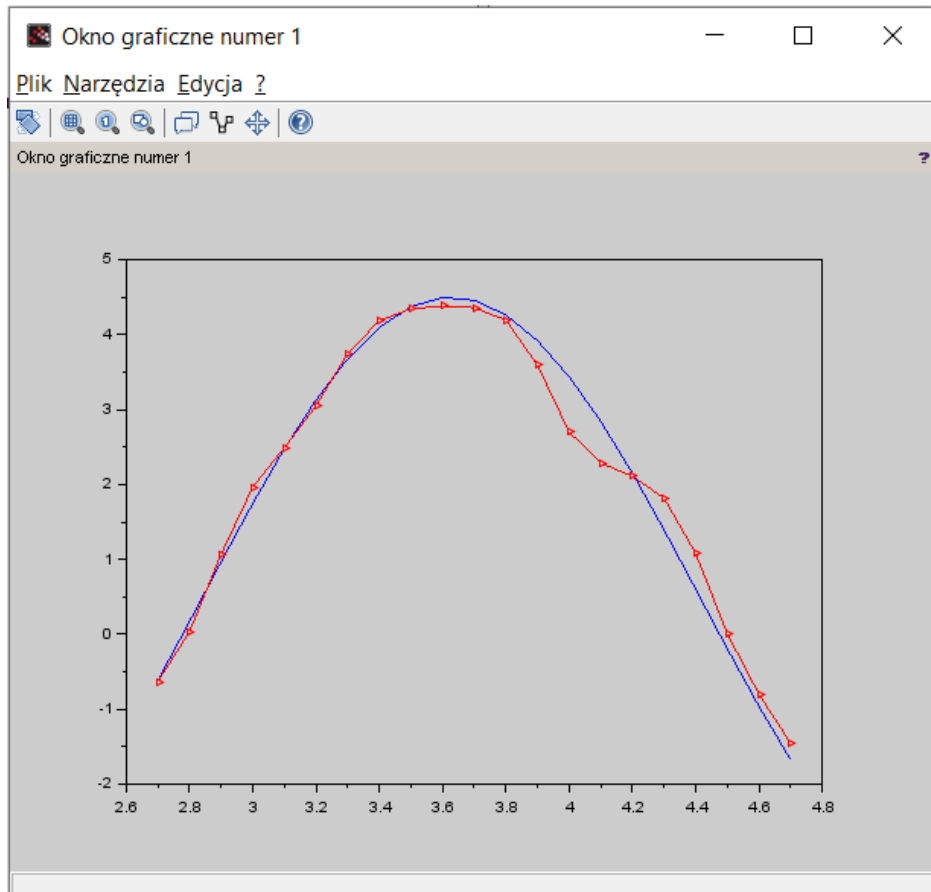
Graph1.Theoretical and real values

In the *Graph1* blue line — theoretical values, red line — real values.

Graph2. Error depending on the epoch

Testing 20 points.

	e	output
1	-0,61766	-0,63095
2	0,167642	0,03244
3	0,966197	1,064853
4	1,746165	1,964094
5	2,476453	2,489546
6	3,127946	3,048792
7	3,674671	3,747135
8	4,094832	4,186971
9	4,371679	4,343712
10	4,494173	4,382405
11	4,457433	4,358629
12	4,262922	4,19308
13	3,918396	3,590962
14	3,437588	2,698309
15	2,839669	2,282251
16	2,148474	2,11213
17	1,39156	1,814846
18	0,599102	1,076227
19	-0,19731	0,002291
20	-0,96592	-0,80348

Tab3. Theoretical and testing outputs

2. Training 50 points.

	Y
1	1,294677
2	2,057673
3	2,75857
4	3,369424
5	3,865884
6	4,228156
7	4,441799
8	4,498294
9	4,395391
10	4,13719
11	3,733986
12	3,201853
13	2,562005
14	1,839953
15	1,06448
16	0,266503
17	-0,52216
18	-1,27008
19	-1,94743
20	-2,52721
21	-2,9863
22	-3,30641

23	-3,47476
24	-3,48466
25	-3,3357
26	-3,03382
27	-2,59106
28	-2,02507
29	-1,35841
30	-0,61766
31	0,167642
32	0,966197
33	1,746165
34	2,476453
35	3,127946
36	3,674671
37	4,094832
38	4,371679
39	4,494173
40	4,457433
41	4,262922
42	3,918396
43	3,437588
44	2,839669
45	2,148474
46	1,39156
47	0,599102
48	-0,19731
49	-0,96592
50	-1,67608
51	-2,2995
52	-2,81131
53	-3,1911
54	-3,42375
55	-3,49996
56	-3,41671
57	-3,17731
58	-2,79131
59	-2,2741
60	-1,64629
61	-0,93292
62	-0,16242
63	0,634492
64	1,426039
65	2,180668
66	2,868294
67	3,461504
68	3,936647
69	4,274783
70	4,462429

Tab4. Theoretical and training outputs

w(11)	0,04123
w(12)	0,035757
w(13)	-0,01734
v(1)	-0,07195
w(21)	-0,00095
w(22)	-0,0161
w(23)	0,072524
v(2)	-0,04285
w(31)	-0,04976
w(32)	-0,03222
w(33)	-0,02156
v(3)	-0,00637

Tab3. Testing outputs

Initial thresholds are taken as 0.
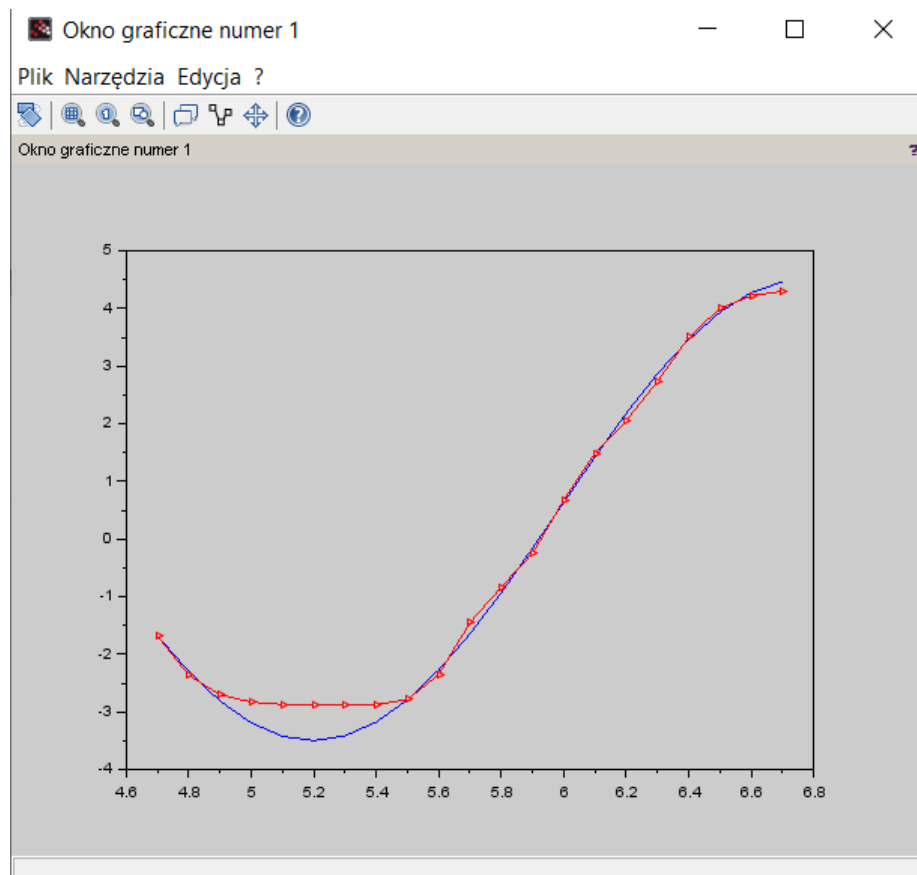
Graph3. Theoretical and real values
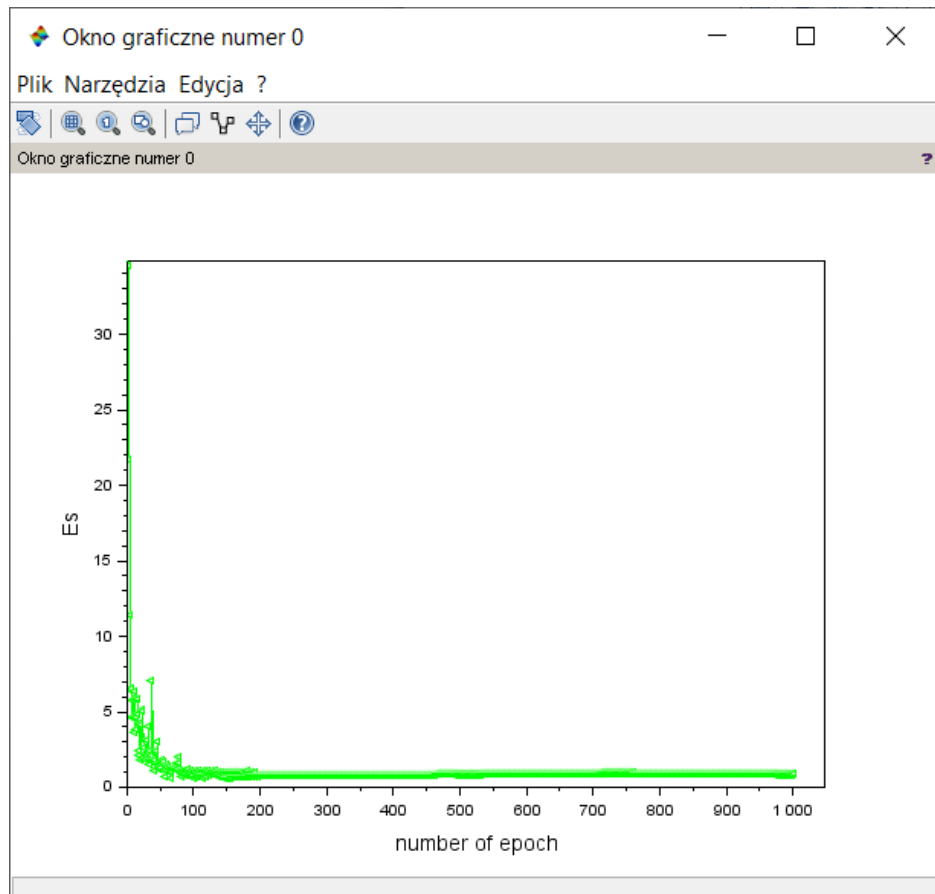
Graph4. Error depending on the epoch

Testing 20 points.

	E	output
1	-1.676084	-1.683831
2	-2.299499	-2.362015
3	-2.811306	-2.703443
4	-3.191102	-2.829766
5	-3.423745	-2.872717
6	-3.499961	-2.887127
7	-3.416711	-2.889514
8	-3.177314	-2.875400
9	-2.791314	-2.785656
10	-2.274100	-2.354320
11	-1.646292	-1.452881
12	-0.932917	-0.835271
13	-0.162417	-0.248593
14	0.634492	0.672552
15	1.426039	1.486200
16	2.180668	2.053313
17	2.868294	2.732079
18	3.461504	3.501087
19	3.936647	4.003146
20	4.274783	4.218023
21	4.462429	4.295651

Tab6. Theoretical and testing outputs

3. Training 100 points.

	y
1	1,294677
2	2,057673
3	2,75857
4	3,369424
5	3,865884
6	4,228156
7	4,441799
8	4,498294
9	4,395391
10	4,13719
11	3,733986
12	3,201853
13	2,562005
14	1,839953
15	1,06448
16	0,266503
17	-0,52216
18	-1,27008
19	-1,94743
20	-2,52721
21	-2,9863
22	-3,30641
23	-3,47476
24	-3,48466
25	-3,3357
26	-3,03382
27	-2,59106
28	-2,02507
29	-1,35841
30	-0,61766
31	0,167642
32	0,966197
33	1,746165
34	2,476453
35	3,127946
36	3,674671
37	4,094832
38	4,371679
39	4,494173
40	4,457433
41	4,262922
42	3,918396
43	3,437588
44	2,839669
45	2,148474
46	1,39156
47	0,599102

48	-0,19731
49	-0,96592
50	-1,67608
51	-2,2995
52	-2,81131
53	-3,1911
54	-3,42375
55	-3,49996
56	-3,41671
57	-3,17731
58	-2,79131
59	-2,2741
60	-1,64629
61	-0,93292
62	-0,16242
63	0,634492
64	1,426039
65	2,180668
66	2,868294
67	3,461504
68	3,936647
69	4,274783
70	4,462429
71	4,492107
72	4,362631
73	4,079165
74	3,653008
75	3,101151
76	2,445595
77	1,712473
78	0,931015
79	0,132373
80	-0,65161
81	-1,38969
82	-2,05243
83	-2,61341
84	-3,05027
85	-3,34559
86	-3,4876
87	-3,47064
88	-3,29538
89	-2,96881
90	-2,50395
91	-1,91933
92	-1,23826
93	-0,4879
94	0,301857
95	1,099509
96	1,87326
97	2,592263

98	3,227854
99	3,754695
100	4,151781
101	4,403282
102	4,499172
103	4,435627
104	4,215181
105	3,846623
106	3,344645
107	2,72926
108	2,025002
109	1,259947
110	0,464595
111	-0,32935
112	-1,09022
113	-1,7877
114	-2,39398
115	-2,88488
116	-3,24084
117	-3,44766
118	-3,4971
119	-3,38719
120	-3,12231

Tab7. Theoretical and training outputs

w(11)	-0,03277
w(12)	0,006738
w(13)	-0,05922
v(1)	-0,0682
w(21)	-0,09636
w(22)	-0,01803
w(23)	-0,09788
v(2)	-0,06069
w(31)	-0,04549
w(32)	-0,03125
w(33)	-0,05933
v(3)	-0,03976

Tab8. Testing outputs

Initial thresholds are taken as 0.
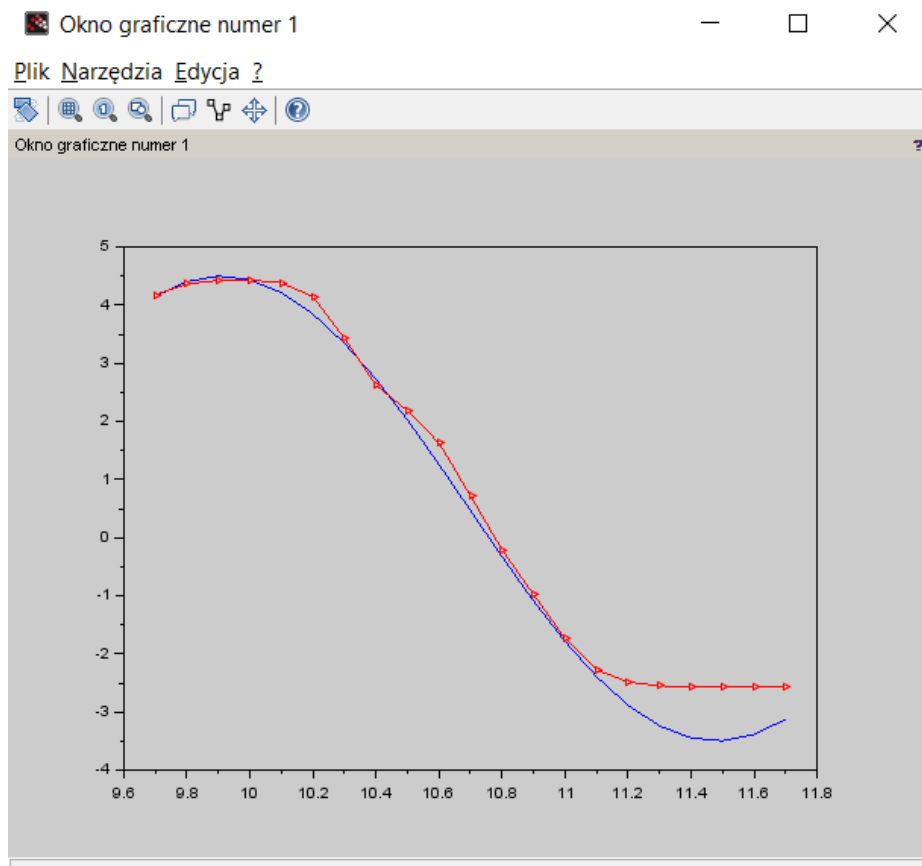
Graph5. Theoretical and real values
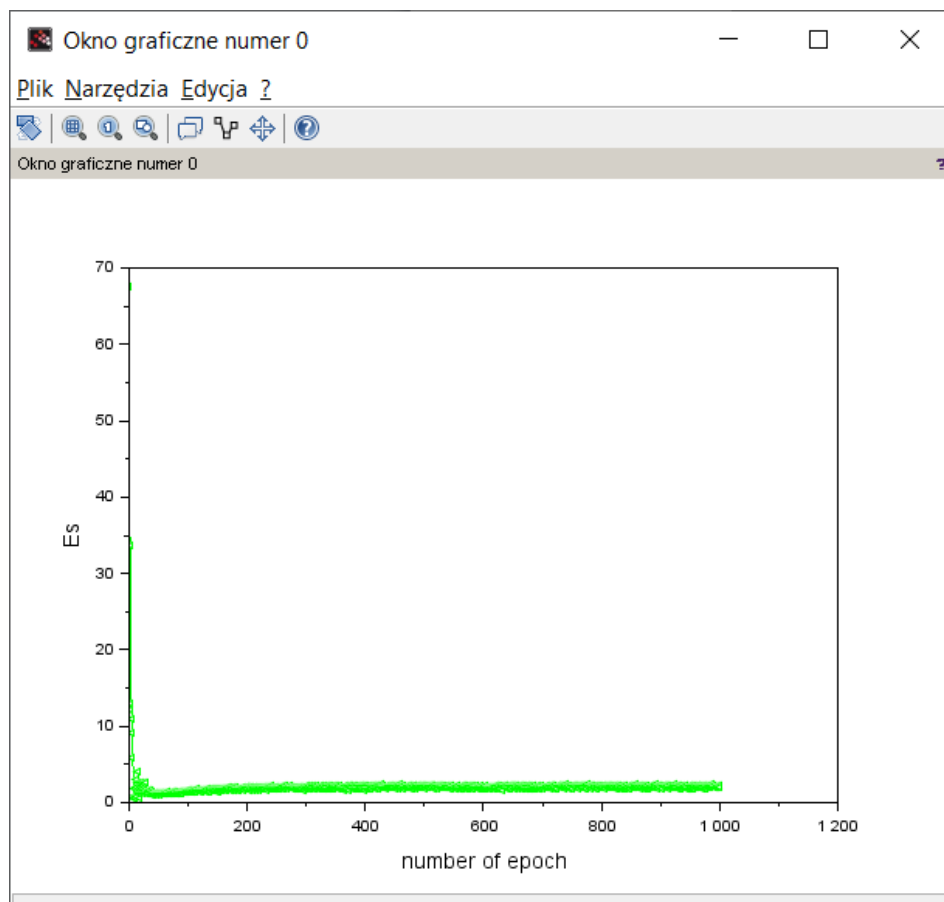
Graph6. Error depending on the epoch

Testing 20 points.

	e	output
1	4.151781	4.173398
2	4.403282	4.363091
3	4.499172	4.422759
4	4.435627	4.430638
5	4.215181	4.383051
6	3.846623	4.147478
7	3.344645	3.429592
8	2.729260	2.627197
9	2.025002	2.180973
10	1.259947	1.627699
11	0.464595	0.720590
12	-0.329346	-0.211326
13	-1.090223	-0.977430
14	-1.787703	-1.739928
15	-2.393979	-2.273937
16	-2.884882	-2.485719
17	-3.240840	-2.549531
18	-3.447662	-2.568046
19	-3.497104	-2.573257
20	-3.387194	-2.573070
21	-3.122313	-2.565640

Tab9. Theoretical and testing outputs

Comparison of results

When training the neural network for 30, 50 and 100 points, it was concluded that the test points that are closest to zero (along the Oy axis) are the closest to the theoretical values. With an increase in the number of training points the mean square error becomes more predictable, which means that the range of its variation becomes smaller.

Code of the program: https://pastebin.com/ZsPTrrEj