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«Вятский государственный университет»

Факультет автоматики и вычислительной техники

Кафедра электронных вычислительных машин

Основы работы в Matlab

Отчет по лабораторной работе №3 дисциплины
«Теория принятия решений»

Выполнил студент группы ИВТ-41 _____/Крючков И. С./
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Киров 2023

1. Задание

Получить выборку в инструментальной оболочке ANIES и проверить её результаты с помощью нейронной сети в среде MatLab.

Выполнить прогнозирование выбора цветка при заданных значениях 7 параметров (входов), используя инструментальную систему ANIES и составить обучающую таблицу для работы в среде MatLab.

С помощью пакета Neural network toolbox создать несколько нейронных сетей и спрогнозировать результаты по полученной в ANIES выборке

2. Выполнение лабораторной работы

ГИПОТЕЗЫ:

Страна {Россия, США, Китай, Индия, Австралия, Норвегия, Гаити, Афганистан}

ПАРАМЕТРЫ:

Численность_населения {низкая, средняя, высокая}

Площадь {малая, средняя, большая}

Климат {тропический, умеренный, смешанный}

Инфраструктура {хорошо_развита, слабо_развита}

Море {да, нет}

Горы {да, нет}

Качество_образования {низкое, среднее, высокое}

Обучающие таблицы

Входы:

1	-0.4500	0.4500	-0.6000	-1	0.6000	-0.4500	0.4500	0.3500	-0.3500	-0.3500	-1	-1	1	-0.7500	-0.7500	0.7500	1	-1
2	-0.9500	0.9500	0.6000	-0.2500	-0.6000	-0.9500	0.9500	0.2000	-0.2000	-0.2000	-0.2500	-0.2500	0.2500	-0.1500	-0.1500	0.1500	0.2000	-0.2000
3	-0.2500	0.2500	-0.1500	-0.7500	-0.1500	-0.2500	0.2500	-1	1	-1	-0.7500	-0.7500	0.7500	0.6500	-0.6500	-0.6500	0.9000	-0.9000
4	-0.6000	0.6000	0.2000	-0.2500	-0.2000	-0.6000	0.6000	-0.6500	0.6500	-0.6500	-0.2500	-0.2500	0.2500	-0.7500	-0.7500	0.7500	0.8500	-0.8500
5	-0.5000	0.5000	-0.7000	-0.6500	-0.7000	-0.5000	0.5000	-0.4500	0.4500	-0.4500	0.6500	-0.6500	-0.6500	1	-1	-1	0.4500	-0.4500
6	-0.5500	0.5500	0.2500	-0.7500	-0.2500	-0.5500	0.5500	-0.6000	0.6000	-0.6000	0.7500	-0.7500	-0.7500	0.1000	-0.1000	-0.1000	-0.5000	0.5000
7	0.2500	-0.2500	-0.9000	-0.8000	0.9000	0.2500	-0.2500	0.4500	-0.4500	-0.4500	0.8000	-0.8000	-0.8000	0.9500	-0.9500	-0.9500	-0.1500	0.1500
8	0.2500	-0.2500	0.7000	-0.9000	-0.7000	0.2500	-0.2500	0.5000	-0.5000	-0.5000	0.9000	-0.9000	-0.9000	-0.4500	0.4500	-0.4500	-0.6000	0.6000
9	0.7500	-0.7500	-0.3000	-0.1500	0.3000	0.7500	-0.7500	0.8000	-0.8000	-0.8000	0.1500	-0.1500	-0.1500	0.1000	-0.1000	-0.1000	-0.4500	0.4500
10	-0.1500	0.1500	-0.2500	0.1500	-0.2500	-0.1500	0.1500	-0.1500	-0.1500	0.1500	-0.1500	-0.1500	-0.1500	-0.1500	0.7000	-0.7000	-0.7000	-0.5500
11	-0.6500	0.6500	-0.1500	-0.1000	0.1500	-0.6500	0.6500	-0.1000	0.1000	-0.1000	-0.1000	-0.1000	-0.1000	-0.1000	-0.9000	0.9000	-0.9000	-0.7500
12	0.6000	-0.6000	0.6000	-0.8000	-0.6000	0.6000	-0.6000	-0.6500	-0.6500	0.6500	-0.8000	-0.8000	-0.8000	0.8000	-0.4500	0.4500	-0.4500	-0.3000
13	-1	1	-0.1000	0.8500	-0.1000	-1	1	-0.5000	0.5000	-0.5000	-0.8500	0.8500	-0.8500	-0.5500	0.5500	-0.5500	0.6000	-0.6000
14	0.5000	-0.5000	-0.8500	-0.5500	0.8500	0.5000	-0.5000	-0.6000	0.6000	-0.6000	-0.5500	-0.5500	0.5500	-0.8000	0.8000	-0.8000	-0.5500	0.5500
15	-0.5500	0.5500	-0.2500	-0.6000	0.2500	-0.5500	0.5500	-0.3000	0.3000	-0.3000	-0.6000	-0.6000	0.6000	0.8500	-0.8500	-0.8500	0.8500	-0.8500
16	-1	1	0.8000	-0.9500	-0.8000	-1	1	-0.7500	-0.7500	0.7500	0.9500	-0.9500	-0.9500	0.6500	-0.6500	-0.6500	0.9000	-0.9000
17	0.2500	-0.2500	0.9500	-0.2000	-0.9500	0.2500	-0.2500	-0.6000	-0.6000	0.6000	-0.2000	-0.2000	0.2000	-0.5000	0.5000	-0.5000	-0.7000	0.7000
18	-1	1	0.3500	-0.7500	-0.3500	-1	1	-0.6000	0.6000	-0.6000	0.7500	-0.7500	-0.7500	0.5000	-0.5000	-0.5000	0.3000	-0.3000
19	-0.9500	0.9500	-0.9000	-0.7500	0.9000	-0.9500	0.9500	0.8500	-0.8500	-0.8500	0.7500	-0.7500	-0.7500	-1	1	-1	-0.7000	0.7000
20	-0.5500	0.5500	-0.8000	-0.9500	0.8000	-0.5500	0.5500	-1	1	-1	0.9500	-0.9500	-0.9500	-0.2500	0.2500	-0.2500	0.2500	-0.2500
21	0.6500	-0.6500	0.8500	-0.6000	-0.8500	0.6500	-0.6500	-0.1500	-0.1500	0.1500	-0.6000	-0.6000	0.6000	0.8500	-0.8500	-0.8500	-0.7000	0.7000
22	-0.3000	0.3000	-0.2000	-0.2000	-0.2000	-0.3000	0.3000	-0.8500	0.8500	-0.8500	-0.2000	-0.2000	0.2000	-0.9000	0.9000	-0.9000	-0.8500	0.8500
23	-0.8000	0.8000	-0.5000	0.1500	0.5000	-0.8000	0.8000	0.7500	-0.7500	-0.7500	-0.1500	-0.1500	-0.1500	0.6000	-0.6000	-0.6000	-1	1
24	-1	1	0.2500	-0.8000	-0.2500	-1	1	1	-1	-1	0.8000	-0.8000	-0.8000	-0.6000	-0.6000	0.6000	0.8000	-0.8000
25	-0.9000	0.9000	-0.3500	-0.1500	0.3500	-0.9000	0.9000	-0.1500	-0.1500	0.1500	0.1500	-0.1500	-0.1500	0.2500	-0.2500	-0.2500	0.2500	-0.2500

Рисунок 1 – Значения входов нейронной сети

Выходы:

1	-0.3640	0.9337	-0.3660	-0.8450	-0.5457	-0.2732	-0.7274	-0.6366
2	0.0703	-0.1587	0.3626	-0.7154	-0.2380	0.1908	-0.2666	-0.2920
3	0.1755	-0.4352	-0.5732	-0.6521	-0.6429	0.0977	-0.7533	-0.7771
4	0.4969	-0.8122	-0.3964	-0.6956	-0.5142	0.4310	-0.5676	-0.6741
5	-0.3810	-0.4389	-0.7582	0.3984	-0.5553	-0.6146	-0.4229	-0.5999
6	-0.5655	0.7370	0.2808	-0.7418	-0.5896	-0.3334	-0.6635	-0.6326
7	0.4416	-0.6706	0.0088	-0.8884	-0.1961	0.1842	-0.4237	-0.3460
8	-0.5857	0.2959	0.6149	-0.8523	-0.5734	0.0163	-0.5444	-0.5325
9	0.2668	-0.7478	-0.2651	-0.5712	-0.2267	0.2231	-0.2668	-0.0845
10	-0.1751	0.3060	-0.3373	-0.0720	-0.2973	-0.3159	-0.2424	-0.2495
11	-0.4111	0.7512	-0.2291	-0.5347	-0.5003	-0.3405	-0.3120	-0.3609
12	0.4865	-0.9509	-0.8183	-0.9260	-0.7285	0.5906	-0.7811	-0.4016
13	-0.3343	0.8601	-0.5176	-0.6075	-0.6986	-0.5636	-0.7788	-0.7337
14	-0.4297	0.7955	-0.4361	-0.8511	-0.4083	-0.3893	-0.5435	-0.5234
15	-0.2429	0.7738	-0.3226	-0.6259	-0.4171	-0.2860	-0.5418	-0.4944
16	-0.6655	0.7299	0.4864	-0.9615	-0.8216	0.3373	-0.8887	-0.8401
17	-0.1559	0.5109	-0.4061	-0.9175	-0.4964	0.3140	-0.5132	-0.2427
18	-0.4814	0.7735	0.1777	-0.7644	-0.5824	-0.2071	-0.6675	-0.6481
19	0.0353	-0.7600	0.5063	-0.9441	-0.6625	0.3381	-0.6006	-0.6912
20	0.4282	-0.4930	-0.5042	-0.8936	-0.4809	0.3839	-0.7026	-0.7135
21	-0.2732	0.6506	0.0375	-0.9005	-0.4766	-0.0563	-0.6220	-0.5682
22	-0.5378	0.6630	-0.5019	-0.3922	-0.7893	-0.5782	-0.7402	-0.7292
23	0.5814	-0.7583	-0.4030	-0.6617	-0.2104	0.3731	-0.2654	-0.4271
24	-0.5005	0.5123	0.5194	-0.7216	-0.5653	-0.1561	-0.6812	-0.6233
25	0.7096	-0.9403	-0.4866	-0.6242	-0.2922	0.5499	-0.2741	-0.5419

Рисунок 2 – Значения выходов нейронной сети

Результаты обучения нейронных сетей:

Обучение с помощью Levenberg-Marquardt

The screenshot displays the MATLAB Neural Network Designer window. The 'Training' tab is active, showing the 'Training Results' section. The training process has completed successfully, reaching the minimum gradient. The 'Training Progress' table shows the following data:

Unit	Initial Value	Stopped Value	Target Value
Epoch	0	7	1000
Elapsed Time	-	00:00:00	-
Performance	1.09	8.19e-20	0
Gradient	1.13	1.85e-10	1e-07
Mu	0.001	1e-09	1e+10
Validation Checks	0	6	6

The 'Model Summary' section on the right provides additional details about the model configuration and performance. The training data is split into 70% training and 30% test data. The model uses the Levenberg-Marquardt algorithm with a mean squared error performance metric. The training results table shows the following data:

	Observations	MSE	R
Training	17	0.1248	0.6733
Validation	4	0.1155	0.6452
Test	4	0.3002	0.1226

The 'Additional Test Results' section shows the performance of the model on a new test set. The test results table shows the following data:

	Observations	MSE	R
Additional test	10	0.1445	0.6693

Рисунок 3 – Окно обучения сети

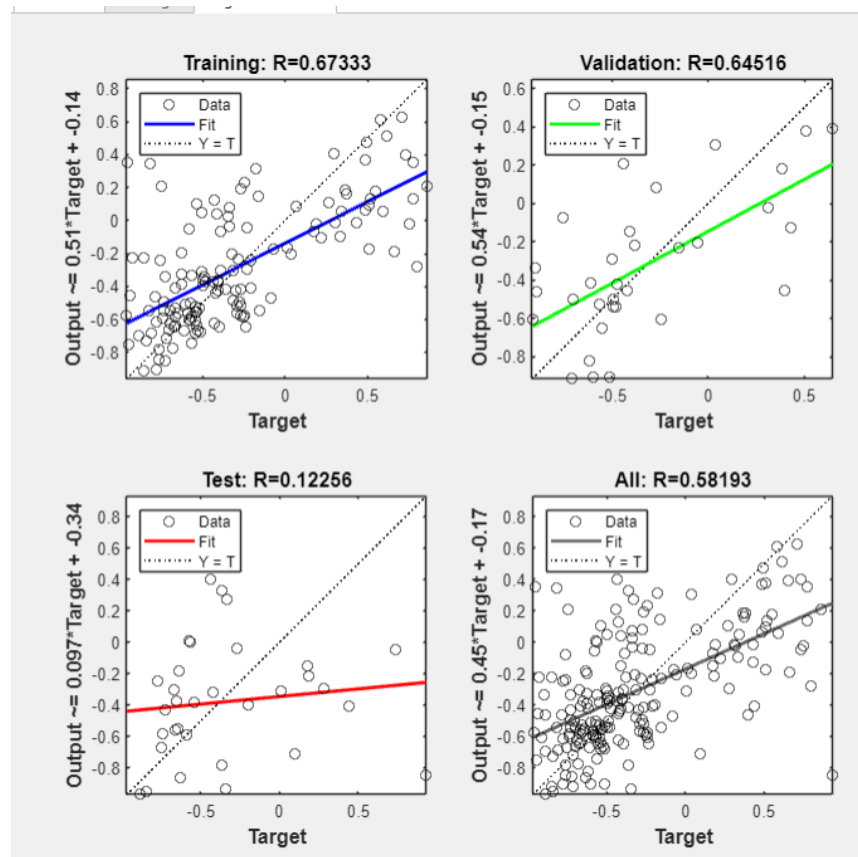


Рисунок 4 – Диаграмма Regression

Средняя погрешность сети: 0,1445

Прогноз сети

№	OUT1		OUT2		OUT3		OUT4		OUT5		OUT6		OUT7		OUT8	
	Ani es	NP	Ani es	NP	Ani es	NP	Ani es	NP	Ani es	NP	Anie s	NP	Ani es	NP	Ani es	NP
1	- 0.36 40	- 0.36 46	0.93 37	0.93 36	- 0.36 60	- 0.36 62	- 0.84 50	- 0.84 59	- 0.54 57	- 0.54 58	- 0.27 32	- 0.27 34	- 0.72 74	- 0.72 76	- 0.63 66	- 0.63 69
2	0.49 69	0.49 70	- 0.81 22	- 0.81 27	- 0.39 64	- 0.39 64	- 0.69 56	- 0.69 48	- 0.51 42	- 0.51 44	0.43 10	0.43 10	- 0.56 76	- 0.56 78	- 0.67 41	- 0.67 39
3	- 0.17 51	- 0.17 51	0.30 60	0.30 58	- 0.33 73	- 0.33 73	- 0.07 20	- 0.07 19	- 0.29 73	- 0.29 73	- 0.31 59	- 0.31 57	- 0.24 24	- 0.24 24	- 0.24 95	- 0.24 95
4	0.48 65	0.35 03	- 0.95 09	- 0.57 59	- 0.81 83	- 0.68 70	- 0.92 60	- 1.10 58	- 0.72 85	- 0.72 22	0.59 06	0.42 25	- 0.78 11	- 0.63 34	- 0.40 16	- 0.66 61
5	0.58 14	0.16 73	- 0.75 83	- 0.74 82	- 0.40 30	- 0.33 84	- 0.66 17	- 0.46 74	- 0.21 04	- 0.19 64	0.37 361	0.17 82	- 0.26 54	- 0.25 60	0.42 71	0.26 15
d	0.1102		0.2171		0.07718		0.07518		0.00412		0.07278		0.03158		0.0861	

Обучение с помощью Scaled Conjugate Gradient

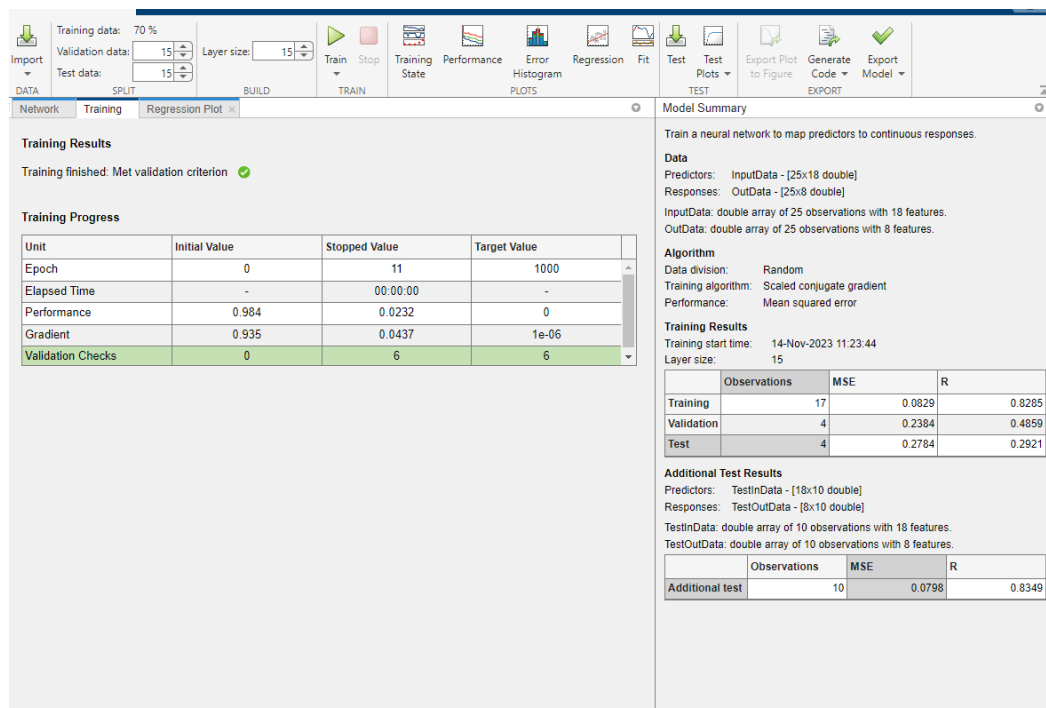


Рисунок 5 – Окно обучения сети

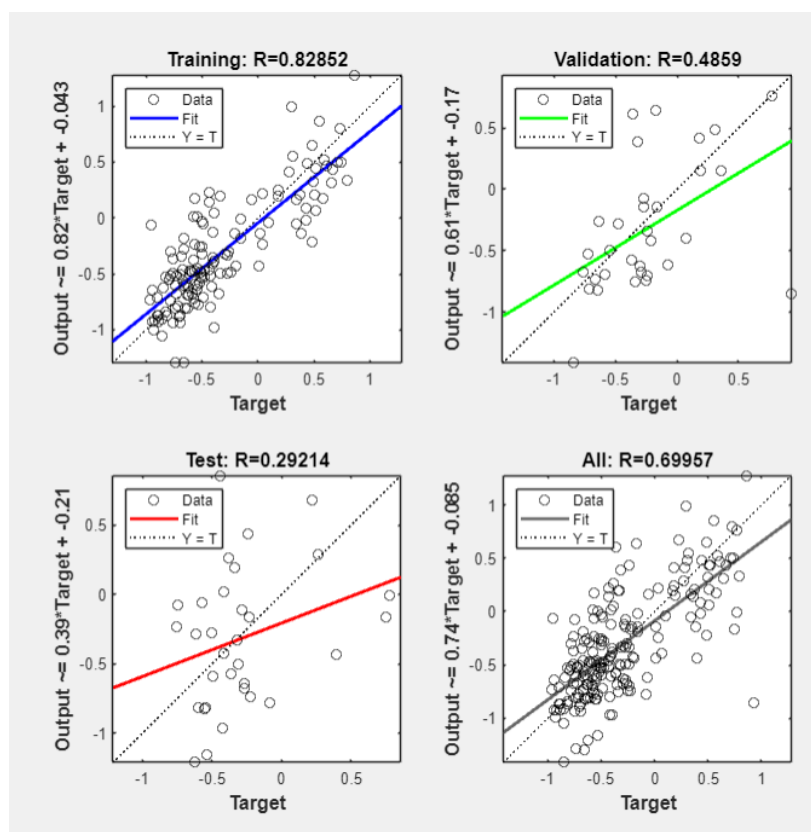


Рисунок 6 – Диаграмма Regression

Средняя погрешность сети: 0,0798

Прогноз сети

№	OUT1		OUT2		OUT3		OUT4		OUT5		OUT6		OUT7		OUT8	
	Ani es	NP	Ani es	NP	Ani es	NP	Ani es	NP	Ani es	NP	Ani es	NP	Ani es	NP	Ani es	NP
1	- 0.36 40	- 0.21 07	0.93 37	0.24 06	- 0.36 60	- 0.38 86	- 0.84 50	- 1.10 89	- 0.54 57	- 0.31 33	- 0.27 32	- 0.21 13	- 0.72 74	- 0.45 56	- 0.63 66	- 0.41 40
2	0.49 69	0.39 07	- 0.81 22	- 0.68 78	- 0.39 64	- 0.10 38	- 0.69 56	- 1.25 49	- 0.51 42	- 0.62 91	0.43 10	0.17 77	- 0.56 76	- 0.20 29	- 0.67 41	- 0.34 15
3	- 0.17 51	- 0.57 45	0.30 60	0.31 38	- 0.33 73	- 0.76 13	- 0.07 20	- 0.26 06	- 0.29 73	- 0.61 33	- 0.31 59	- 0.25 24	- 0.24 24	- 0.70 39	- 0.24 95	- 0.20 46
4	0.48 65	0.36 26	- 0.95 09	- 0.84 54	- 0.81 83	- 0.22 34	- 0.92 60	- 0.78 10	- 0.72 85	- 0.44 72	0.59 06	0.49 03	- 0.78 11	- 0.39 92	- 0.40 16	- 0.29 44
5	0.58 14	0.32 35	- 0.75 83	- 0.84 53	- 0.40 30	- 0.47 82	- 0.66 17	- 0.46 25	- 0.21 04	- 0.09 73	0.37 361	0.43 87	- 0.26 54	- 0.35 83	0.42 71	0.56 41
d	0.20814		0.20356		0.28186		0.2712		0.21154		0.108818		0.3146		0.16886	

Обучение с помощью Bayesian Regularization

Training Results

Training finished: Reached minimum gradient ✓

Training Progress

Unit	Initial Value	Stopped Value	Target Value
Epoch	0	430	1000
Elapsed Time	-	00:00:08	-
Performance	1.23	1.76e-14	0
Gradient	1.09	9.98e-08	1e-07
Mu	0.005	5	1e+10
Effective # Param	413	168	0
Sum Squared Param	95.6	36	0

Model Summary

Train a neural network to map predictors to continuous responses.

Data
Predictors: InputData - [25x18 double]
Responses: OutData - [25x8 double]
InputData: double array of 25 observations with 18 features.
OutData: double array of 25 observations with 8 features.

Algorithm
Data division: Random
Training algorithm: Bayesian regularization
Performance: Mean squared error

Training Results
Training start time: 14-Nov-2023 11:28:52
Layer size: 15

	Observations	MSE	R
Training	21	0.0000	1.0000
Validation	0	NaN	NaN
Test	4	0.3027	0.3042

Additional Test Results
Predictors: TestInData - [18x10 double]
Responses: TestOutData - [8x10 double]
TestInData: double array of 10 observations with 18 features.
TestOutData: double array of 10 observations with 8 features.

	Observations	MSE	R
Additional test	10	0.0729	0.8559

Рисунок 7 – Окно обучения сети

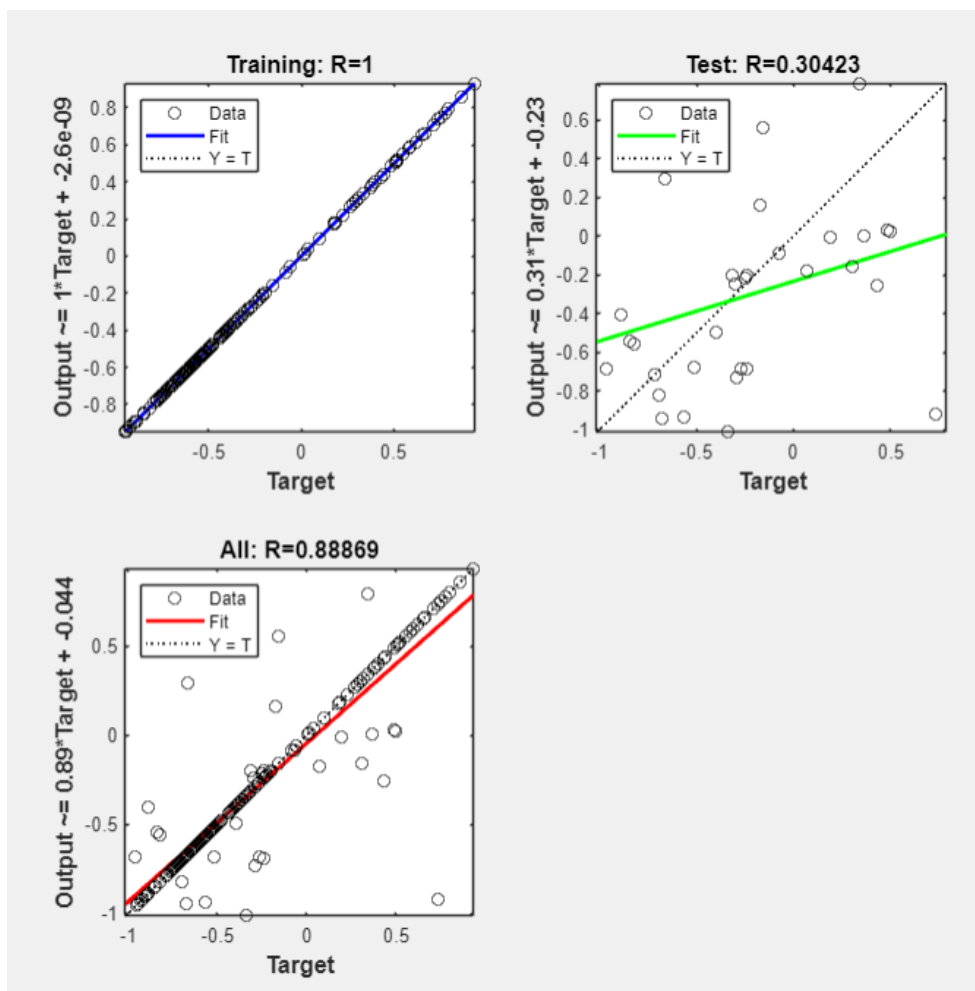


Рисунок 8 – Диаграмма Regression

Средняя погрешность сети: 0,0729

Прогноз сети

№	OUT1		OUT2		OUT3		OUT4		OUT5		OUT6		OUT7		OUT8	
	Ani es	NP	Ani es	NP	Ani es	NP	Ani es	NP	Ani es	NP	Anie s	NP	Ani es	NP	Ani es	NP
1	- 0.36 40	- 0.38 17	0.93 37	0.91 84	- 0.36 60	- 0.37 17	- 0.84 50	- 0.85 53	- 0.54 57	- 0.53 60	- 0.27 32	- 0.26 76	- 0.72 74	- 0.69 99	- 0.63 66	- 0.62 97
2	0.49 69	0.50 84	- 0.81 22	- 0.80 13	- 0.39 64	- 0.38 77	- 0.69 56	- 0.68 30	- 0.51 42	- 0.51 88	0.43 10	0.43 22	- 0.56 76	- 0.58 08	- 0.67 41	- 0.66 68
3	- 0.17 51	- 0.20 03	0.30 60	0.28 92	- 0.33 73	- 0.35 99	- 0.07 20	- 0.09 69	- 0.29 73	- 0.25 71	- 0.31 59	- 0.33 04	- 0.24 24	- 0.23 71	- 0.24 95	- 0.26 98
4	0.48 65	0.47 16	- 0.95 09	- 0.94 91	- 0.81 83	- 0.81 59	- 0.92 60	- 0.93 24	- 0.72 85	- 0.71 02	0.59 06	0.59 29	- 0.78 11	- 0.76 45	- 0.40 16	- 0.42 34
5	0.58 14	0.58 90	- 0.75 83	- 0.75 29	- 0.40 30	- 0.39 71	- 0.66 17	- 0.65 66	- 0.21 04	- 0.22 12	0.37 361	0.36 87	- 0.26 54	- 0.26 12	0.42 71	0.40 62
d	0.01538		0.01004		0.00906		0.01186		0.01672		0.005702		0.01336		0.01544	

Вывод

Самой оптимальной сетью среди протестированных является Bayesian Regularization с 15 нейронами, так как она имеет наименьшую погрешность на тестовых данных.