

# Discrete-event Simulation Assignment 2

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**Notes:** The Confusion Matrix for each perceptron is formatted in the same way as the one generated by the code in the previous assignment. I wasn't able to figure out how to label them in a reasonable fashion in LaTeX. I ran the training data until I reach an epoch that failed to improve the training accuracy over the previous cycle. Additional cycles do occasionally produce improvements, but this method seemed the easiest to manage and apply consistently.

**Learning Rate 0.20:** Data from the training and testing.

Perceptron	0	1
Number of Epochs		6
Training Accuracy		1.000
Test Accuracy		0.984
Confusion Matrix	91	0
	3	92

Perceptron	0	2
Number of Epochs		7
Training Accuracy		1.000
Test Accuracy		1.000
Confusion Matrix	94	0
	0	95

Perceptron	0	3
Number of Epochs		5
Training Accuracy		1.000
Test Accuracy		0.985
Confusion Matrix	105	0
	3	92

Perceptron	0	4
Number of Epochs		5
Training Accuracy		0.990
Test Accuracy		0.905
Confusion Matrix	84	0
	17	78

Perceptron	0	5
Number of Epochs		5
Training Accuracy		0.990
Test Accuracy		0.896
Confusion Matrix	88	0
	19	76

Perceptron	0	6
Number of Epochs		6
Training Accuracy		1.000
Test Accuracy		0.989
Confusion Matrix	89	2
	0	95

Perceptron	0	7
Number of Epochs		5
Training Accuracy		1.000
Test Accuracy		0.984
Confusion Matrix	94	0
	3	92

Perceptron	0	9
Number of Epochs		5
Training Accuracy		1.000
Test Accuracy		0.980
Confusion Matrix	104	0
	4	91

Perceptron	1	3
Number of Epochs		6
Training Accuracy		1.000
Test Accuracy		0.990
Confusion Matrix	105	0
	2	89

Perceptron	1	5
Number of Epochs		5
Training Accuracy		0.990
Test Accuracy		0.542
Confusion Matrix	88	0
	82	9

Perceptron	1	7
Number of Epochs		5
Training Accuracy		0.991
Test Accuracy		0.903
Confusion Matrix	94	0
	18	73

Perceptron	1	9
Number of Epochs		6
Training Accuracy		0.990
Test Accuracy		0.656
Confusion Matrix	104	0
	67	24

Perceptron	0	8
Number of Epochs		5
Training Accuracy		0.989
Test Accuracy		0.923
Confusion Matrix	88	0
	14	81

Perceptron	1	2
Number of Epochs		5
Training Accuracy		0.990
Test Accuracy		0.935
Confusion Matrix	94	0
	12	79

Perceptron	1	4
Number of Epochs		5
Training Accuracy		0.990
Test Accuracy		0.480
Confusion Matrix	84	0
	91	0

Perceptron	1	6
Number of Epochs		5
Training Accuracy		0.991
Test Accuracy		0.984
Confusion Matrix	89	2
	1	90

Perceptron	1	8
Number of Epochs		5
Training Accuracy		0.980
Test Accuracy		0.575
Confusion Matrix	88	0
	76	15

Perceptron	2	3
Number of Epochs		5
Training Accuracy		0.990
Test Accuracy		0.789
Confusion Matrix	105	0
	42	52

Perceptron	2	4
Number of Epochs		6
Training Accuracy		1.000
Test Accuracy		0.994
Confusion Matrix	83	1
	0	94

Perceptron	2	6
Number of Epochs		5
Training Accuracy		0.990
Test Accuracy		1.000
Confusion Matrix	91	0
	0	94

Perceptron	2	8
Number of Epochs		5
Training Accuracy		0.990
Test Accuracy		0.835
Confusion Matrix	88	0
	30	64

Perceptron	3	4
Number of Epochs		5
Training Accuracy		1.000
Test Accuracy		0.979
Confusion Matrix	80	4
	0	105

Perceptron	3	6
Number of Epochs		5
Training Accuracy		1.000
Test Accuracy		0.995
Confusion Matrix	90	1
	0	105

Perceptron	3	8
Number of Epochs		5
Training Accuracy		0.989
Test Accuracy		0.896
Confusion Matrix	88	0
	20	85

Perceptron	2	5
Number of Epochs		5
Training Accuracy		0.990
Test Accuracy		0.505
Confusion Matrix	88	0
	90	4

Perceptron	2	7
Number of Epochs		5
Training Accuracy		1.000
Test Accuracy		0.979
Confusion Matrix	94	0
	4	90

Perceptron	2	9
Number of Epochs		6
Training Accuracy		0.990
Test Accuracy		0.707
Confusion Matrix	104	0
	58	36

Perceptron	3	5
Number of Epochs		5
Training Accuracy		0.984
Test Accuracy		0.513
Confusion Matrix	88	0
	94	11

Perceptron	3	7
Number of Epochs		5
Training Accuracy		0.990
Test Accuracy		1.000
Confusion Matrix	94	0
	0	105

Perceptron	3	9
Number of Epochs		5
Training Accuracy		0.990
Test Accuracy		0.598
Confusion Matrix	104	0
	84	21

Perceptron	4	5
Number of Epochs		5
Training Accuracy		0.990
Test Accuracy		0.808
Confusion Matrix	88	0
	33	51
Perceptron	4	7
Number of Epochs		6
Training Accuracy		0.990
Test Accuracy		0.781
Confusion Matrix	94	0
	39	45
Perceptron	4	9
Number of Epochs		5
Training Accuracy		0.990
Test Accuracy		0.612
Confusion Matrix	104	0
	73	11
Perceptron	5	7
Number of Epochs		6
Training Accuracy		1.000
Test Accuracy		1.000
Confusion Matrix	94	0
	0	88
Perceptron	5	9
Number of Epochs		5
Training Accuracy		0.990
Test Accuracy		0.568
Confusion Matrix	104	0
	83	5
Perceptron	6	8
Number of Epochs		6
Training Accuracy		0.990
Test Accuracy		0.894
Confusion Matrix	88	0
	19	72
Perceptron	4	6
Number of Epochs		6
Training Accuracy		0.990
Test Accuracy		0.863
Confusion Matrix	91	0
	24	60
Perceptron	4	8
Number of Epochs		5
Training Accuracy		0.979
Test Accuracy		0.791
Confusion Matrix	88	0
	36	48
Perceptron	5	6
Number of Epochs		6
Training Accuracy		1.000
Test Accuracy		0.989
Confusion Matrix	90	1
	1	87
Perceptron	5	8
Number of Epochs		5
Training Accuracy		0.990
Test Accuracy		0.500
Confusion Matrix	88	0
	88	0
Perceptron	6	7
Number of Epochs		5
Training Accuracy		1.000
Test Accuracy		1.000
Confusion Matrix	94	0
	0	91
Perceptron	6	9
Number of Epochs		5
Training Accuracy		1.000
Test Accuracy		0.995
Confusion Matrix	104	0
	1	90

Perceptron	7	8
Number of Epochs		5
Training Accuracy		1.000
Test Accuracy		0.984
Confusion Matrix	88	0
	3	91

Perceptron	8	9
Number of Epochs		5
Training Accuracy		0.990
Test Accuracy		0.682
Confusion Matrix	103	1
	60	28

Perceptron	7	9
Number of Epochs		5
Training Accuracy		0.990
Test Accuracy		0.884
Confusion Matrix	104	0
	23	71

**Summary** For learning rate 0.20 the total accuracy on the training data was 0.993, and the total accuracy on the test data was 0.841. The average number of epochs needed by each perceptron was 5.289.

**Learning Rate 0.80:** Data from the training and testing.

Perceptron	0	1
Number of Epochs		6
Training Accuracy		1.000
Test Accuracy		0.984
Confusion Matrix	91	0
	3	92

Perceptron	0	3
Number of Epochs		5
Training Accuracy		1.000
Test Accuracy		0.985
Confusion Matrix	105	0
	3	92

Perceptron	0	5
Number of Epochs		5
Training Accuracy		0.990
Test Accuracy		0.814
Confusion Matrix	88	0
	34	61

Perceptron	0	2
Number of Epochs		5
Training Accuracy		0.990
Test Accuracy		0.571
Confusion Matrix	94	0
	81	14

Perceptron	0	4
Number of Epochs		5
Training Accuracy		0.990
Test Accuracy		0.922
Confusion Matrix	83	1
	13	82

Perceptron	0	6
Number of Epochs		6
Training Accuracy		1.000
Test Accuracy		0.946
Confusion Matrix	81	10
	0	95

Perceptron	0	7
Number of Epochs		5
Training Accuracy		1.000
Test Accuracy		0.989
Confusion Matrix	94	0
	2	93
Perceptron	0	9
Number of Epochs		5
Training Accuracy		1.000
Test Accuracy		0.990
Confusion Matrix	104	0
	2	93
Perceptron	1	3
Number of Epochs		6
Training Accuracy		1.000
Test Accuracy		0.995
Confusion Matrix	105	0
	1	90
Perceptron	1	5
Number of Epochs		5
Training Accuracy		0.990
Test Accuracy		0.966
Confusion Matrix	88	0
	6	85
Perceptron	1	7
Number of Epochs		5
Training Accuracy		0.986
Test Accuracy		0.605
Confusion Matrix	94	0
	73	18
Perceptron	1	9
Number of Epochs		6
Training Accuracy		0.990
Test Accuracy		0.733
Confusion Matrix	104	0
	52	39
Perceptron	0	8
Number of Epochs		5
Training Accuracy		0.989
Test Accuracy		0.967
Confusion Matrix	88	0
	6	89
Perceptron	1	2
Number of Epochs		5
Training Accuracy		0.990
Test Accuracy		0.984
Confusion Matrix	94	0
	3	88
Perceptron	1	4
Number of Epochs		5
Training Accuracy		0.986
Test Accuracy		0.480
Confusion Matrix	84	0
	91	0
Perceptron	1	6
Number of Epochs		5
Training Accuracy		0.991
Test Accuracy		0.984
Confusion Matrix	89	2
	1	90
Perceptron	1	8
Number of Epochs		5
Training Accuracy		0.980
Test Accuracy		0.564
Confusion Matrix	88	0
	78	13
Perceptron	2	3
Number of Epochs		5
Training Accuracy		0.990
Test Accuracy		0.819
Confusion Matrix	105	0
	36	58

Perceptron	2	4
Number of Epochs		5
Training Accuracy		1.000
Test Accuracy		0.972
Confusion Matrix	84	0
	5	89

Perceptron	2	6
Number of Epochs		6
Training Accuracy		1.000
Test Accuracy		0.978
Confusion Matrix	89	2
	2	92

Perceptron	2	8
Number of Epochs		5
Training Accuracy		0.984
Test Accuracy		0.956
Confusion Matrix	88	0
	8	86

Perceptron	3	4
Number of Epochs		7
Training Accuracy		1.000
Test Accuracy		0.995
Confusion Matrix	83	1
	0	105

Perceptron	3	6
Number of Epochs		6
Training Accuracy		1.000
Test Accuracy		0.985
Confusion Matrix	88	3
	0	105

Perceptron	3	8
Number of Epochs		5
Training Accuracy		0.989
Test Accuracy		0.891
Confusion Matrix	88	0
	21	84

Perceptron	2	5
Number of Epochs		5
Training Accuracy		0.990
Test Accuracy		0.797
Confusion Matrix	88	0
	37	57

Perceptron	2	7
Number of Epochs		5
Training Accuracy		1.000
Test Accuracy		0.984
Confusion Matrix	94	0
	3	91

Perceptron	2	9
Number of Epochs		5
Training Accuracy		0.985
Test Accuracy		0.566
Confusion Matrix	104	0
	86	8

Perceptron	3	5
Number of Epochs		5
Training Accuracy		0.984
Test Accuracy		0.544
Confusion Matrix	88	0
	88	17

Perceptron	3	7
Number of Epochs		5
Training Accuracy		0.990
Test Accuracy		1.000
Confusion Matrix	94	0
	0	105

Perceptron	3	9
Number of Epochs		5
Training Accuracy		0.990
Test Accuracy		0.498
Confusion Matrix	104	0
	105	0

Perceptron	4	5	Perceptron	4	6
Number of Epochs		5	Number of Epochs		7
Training Accuracy		0.990	Training Accuracy		1.000
Test Accuracy		0.895	Test Accuracy		0.989
Confusion Matrix	88	0	Confusion Matrix	89	2
	18	66		0	84
Perceptron	4	7	Perceptron	4	8
Number of Epochs		6	Number of Epochs		5
Training Accuracy		1.000	Training Accuracy		0.979
Test Accuracy		0.961	Test Accuracy		0.686
Confusion Matrix	94	0	Confusion Matrix	88	0
	7	77		54	30
Perceptron	4	9	Perceptron	5	6
Number of Epochs		5	Number of Epochs		5
Training Accuracy		0.990	Training Accuracy		1.000
Test Accuracy		0.553	Test Accuracy		0.994
Confusion Matrix	104	0	Confusion Matrix	90	1
	84	0		0	88
Perceptron	5	7	Perceptron	5	8
Number of Epochs		5	Number of Epochs		5
Training Accuracy		0.990	Training Accuracy		0.990
Test Accuracy		0.797	Test Accuracy		0.500
Confusion Matrix	94	0	Confusion Matrix	88	0
	37	51		88	0
Perceptron	5	9	Perceptron	6	7
Number of Epochs		5	Number of Epochs		5
Training Accuracy		0.990	Training Accuracy		1.000
Test Accuracy		0.552	Test Accuracy		1.000
Confusion Matrix	104	0	Confusion Matrix	94	0
	86	2		0	91
Perceptron	6	8	Perceptron	6	9
Number of Epochs		6	Number of Epochs		5
Training Accuracy		0.990	Training Accuracy		1.000
Test Accuracy		0.888	Test Accuracy		1.000
Confusion Matrix	88	0	Confusion Matrix	104	0
	20	71		0	91



Perceptron	7	8
Number of Epochs		5
Training Accuracy		1.000
Test Accuracy		0.973
Confusion Matrix	87	1
	4	90

Perceptron	7	9
Number of Epochs		5
Training Accuracy		0.990
Test Accuracy		0.667
Confusion Matrix	104	0
	66	28

Perceptron	8	9
Number of Epochs		5
Training Accuracy		0.990
Test Accuracy		0.714
Confusion Matrix	102	2
	53	35

**Summary** For learning rate 0.80 the total accuracy on the training data was 0.993, and the total accuracy on the test data was 0.836. The average number of epochs needed by each perceptron was 5.267.

**Learning Rate 0.05:** Data from the training and testing.

Perceptron	0	1
Number of Epochs		6
Training Accuracy		1.000
Test Accuracy		0.978
Confusion Matrix	91	0
	4	91

Perceptron	0	2
Number of Epochs		5
Training Accuracy		0.985
Test Accuracy		0.995
Confusion Matrix	94	0
	1	94

Perceptron	0	3
Number of Epochs		6
Training Accuracy		1.000
Test Accuracy		0.995
Confusion Matrix	105	0
	1	94

Perceptron	0	4
Number of Epochs		5
Training Accuracy		0.990
Test Accuracy		0.866
Confusion Matrix	84	0
	24	71

Perceptron	0	5
Number of Epochs		5
Training Accuracy		0.990
Test Accuracy		0.847
Confusion Matrix	88	0
	28	67

Perceptron	0	6
Number of Epochs		6
Training Accuracy		1.000
Test Accuracy		1.000
Confusion Matrix	91	0
	0	95

Perceptron	0	7
Number of Epochs		5
Training Accuracy		1.000
Test Accuracy		1.000
Confusion Matrix	94	0
	0	95
Perceptron	0	9
Number of Epochs		5
Training Accuracy		1.000
Test Accuracy		0.990
Confusion Matrix	104	0
	2	93
Perceptron	1	3
Number of Epochs		5
Training Accuracy		0.990
Test Accuracy		0.679
Confusion Matrix	105	0
	63	28
Perceptron	1	5
Number of Epochs		5
Training Accuracy		0.990
Test Accuracy		0.575
Confusion Matrix	88	0
	76	15
Perceptron	1	7
Number of Epochs		5
Training Accuracy		0.991
Test Accuracy		0.865
Confusion Matrix	94	0
	25	66
Perceptron	1	9
Number of Epochs		6
Training Accuracy		0.990
Test Accuracy		0.887
Confusion Matrix	104	0
	22	69
Perceptron	0	8
Number of Epochs		5
Training Accuracy		0.989
Test Accuracy		0.945
Confusion Matrix	88	0
	10	85
Perceptron	1	2
Number of Epochs		5
Training Accuracy		0.990
Test Accuracy		0.973
Confusion Matrix	94	0
	5	86
Perceptron	1	4
Number of Epochs		5
Training Accuracy		0.986
Test Accuracy		0.577
Confusion Matrix	84	0
	74	17
Perceptron	1	6
Number of Epochs		5
Training Accuracy		0.991
Test Accuracy		0.978
Confusion Matrix	89	2
	2	89
Perceptron	1	8
Number of Epochs		5
Training Accuracy		0.980
Test Accuracy		0.570
Confusion Matrix	88	0
	77	14
Perceptron	2	3
Number of Epochs		5
Training Accuracy		0.990
Test Accuracy		0.769
Confusion Matrix	105	0
	46	48

Perceptron	2	4	Perceptron	2	5
Number of Epochs		5	Number of Epochs		5
Training Accuracy		0.990	Training Accuracy		0.990
Test Accuracy		1.000	Test Accuracy		0.731
Confusion Matrix	84	0	Confusion Matrix	88	0
	0	94		49	45
Perceptron	2	6	Perceptron	2	7
Number of Epochs		5	Number of Epochs		7
Training Accuracy		0.990	Training Accuracy		1.000
Test Accuracy		0.995	Test Accuracy		0.984
Confusion Matrix	91	0	Confusion Matrix	92	2
	1	93		1	93
Perceptron	2	8	Perceptron	2	9
Number of Epochs		5	Number of Epochs		5
Training Accuracy		0.990	Training Accuracy		0.990
Test Accuracy		0.709	Test Accuracy		0.970
Confusion Matrix	88	0	Confusion Matrix	104	0
	53	41		6	88
Perceptron	3	4	Perceptron	3	5
Number of Epochs		5	Number of Epochs		5
Training Accuracy		1.000	Training Accuracy		0.984
Test Accuracy		1.000	Test Accuracy		0.777
Confusion Matrix	84	0	Confusion Matrix	88	0
	0	105		43	62
Perceptron	3	6	Perceptron	3	7
Number of Epochs		6	Number of Epochs		5
Training Accuracy		1.000	Training Accuracy		0.990
Test Accuracy		0.995	Test Accuracy		0.472
Confusion Matrix	90	1	Confusion Matrix	94	0
	0	105		105	0
Perceptron	3	8	Perceptron	3	9
Number of Epochs		5	Number of Epochs		5
Training Accuracy		0.989	Training Accuracy		0.990
Test Accuracy		0.974	Test Accuracy		0.646
Confusion Matrix	88	0	Confusion Matrix	104	0
	5	100		74	31

Perceptron	4	5	Perceptron	4	6
Number of Epochs		5	Number of Epochs		6
Training Accuracy		0.990	Training Accuracy		0.990
Test Accuracy		0.924	Test Accuracy		0.983
Confusion Matrix	88	0	Confusion Matrix	91	0
	13	71		3	81
Perceptron	4	7	Perceptron	4	8
Number of Epochs		5	Number of Epochs		5
Training Accuracy		0.990	Training Accuracy		0.990
Test Accuracy		0.955	Test Accuracy		0.878
Confusion Matrix	94	0	Confusion Matrix	88	0
	8	76		21	63
Perceptron	4	9	Perceptron	5	6
Number of Epochs		5	Number of Epochs		5
Training Accuracy		0.990	Training Accuracy		1.000
Test Accuracy		0.707	Test Accuracy		0.989
Confusion Matrix	104	0	Confusion Matrix	90	1
	55	29		1	87
Perceptron	5	7	Perceptron	5	8
Number of Epochs		5	Number of Epochs		7
Training Accuracy		1.000	Training Accuracy		0.990
Test Accuracy		0.973	Test Accuracy		0.938
Confusion Matrix	94	0	Confusion Matrix	88	0
	5	83		11	77
Perceptron	5	9	Perceptron	6	7
Number of Epochs		5	Number of Epochs		5
Training Accuracy		0.980	Training Accuracy		1.000
Test Accuracy		0.578	Test Accuracy		0.984
Confusion Matrix	104	0	Confusion Matrix	94	0
	81	7		3	88
Perceptron	6	8	Perceptron	6	9
Number of Epochs		5	Number of Epochs		5
Training Accuracy		0.990	Training Accuracy		1.000
Test Accuracy		0.531	Test Accuracy		1.000
Confusion Matrix	88	0	Confusion Matrix	104	0
	84	7		0	91

Perceptron	7	8
Number of Epochs		6
Training Accuracy		1.000
Test Accuracy		0.978
Confusion Matrix	88	0
	4	90

Perceptron	7	9
Number of Epochs		5
Training Accuracy		0.990
Test Accuracy		0.960
Confusion Matrix	104	0
	8	86

Perceptron	8	9
Number of Epochs		5
Training Accuracy		0.990
Test Accuracy		0.542
Confusion Matrix	104	0
	88	0

**Summary** For learning rate 0.05 the total accuracy on the training data was 0.992, and the total accuracy on the test data was 0.859. The average number of epochs needed by each perceptron was 5.244.