Artificial Neural Networks

A Perceptron Learning Example

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Perceptron Learning Rule

$$\Delta w_{ij} = \eta\,(targ_j - out_j)\,in_i$$

Example: NAND gate

- Inputs: x1, x2
  - An additional X0, always held 1
- Output: binary
- Patterns:
  - (0,0) => 1
  - (0,1) => 1
  - (1,0) => 1
  - (1,1) => 0
- Learning rate: 0.1

Example: NAND gate (cont.)

Input				Initial weights			Output					Error	Correction	Final weights		
Sensor values			Desired output				Per sensor			Sum	Network					
x_0	x_1	x_2	z	w_0	w_1	w_2	c_0	c_1	c_2	s	n	e	d	w_0	w_1	w_2
							$x_0 * w_0$	$x_1 * w_1$	$x_2 * w_2$	$c_0 + c_1 + c_2$	if $s > t$ then 1, else 0	$z - n$	$r * e$	$\Delta(x_0 * d)$	$\Delta(x_1 * d)$	$\Delta(x_2 * d)$
1	0	0	1	0.3	0.1	0.1	0.3	0	0	0.3	0	1	+0.1	0.4	0.1	0.1
1	0	1	1	0.4	0.1	0.1	0.4	0	0.1	0.5	0	1	+0.1	0.5	0.1	0.2
1	1	0	1	0.5	0.1	0.2	0.5	0.1	0	0.6	1	0	0	0.5	0.1	0.2
1	1	1	0	0.5	0.1	0.2	0.5	0.1	0.2	0.8	1	-1	-0.1	0.4	0	0.1

Example: NAND gate (cont.)

1	0	0	1	0.3	0.1	0.1	0.3	0	0	0.3	0	1	+0.1	0.4	0.1	0.1
1	0	1	1	0.4	0.1	0.1	0.4	0	0.1	0.5	0	1	+0.1	0.5	0.1	0.2
1	1	0	1	0.5	0.1	0.2	0.5	0.1	0	0.6	1	0	0	0.5	0.1	0.2
1	1	1	0	0.5	0.1	0.2	0.5	0.1	0.2	0.8	1	-1	-0.1	0.4	0	0.1
1	0	0	1	0.4	0	0.1	0.4	0	0	0.4	0	1	+0.1	0.5	0	0.1
1	0	1	1	0.5	0	0.1	0.5	0	0.1	0.6	1	0	0	0.5	0	0.1
1	1	0	1	0.5	0	0.1	0.5	0	0	0.5	0	1	+0.1	0.6	0.1	0.1
1	1	1	0	0.6	0.1	0.1	0.6	0.1	0.1	0.8	1	-1	-0.1	0.5	0	0
1	0	0	1	0.5	0	0	0.5	0	0	0.5	0	1	+0.1	0.6	0	0
1	0	1	1	0.6	0	0	0.6	0	0	0.6	1	0	0	0.6	0	0
1	1	0	1	0.6	0	0	0.6	0	0	0.6	1	0	0	0.6	0	0
1	1	1	0	0.6	0	0	0.6	0	0	0.6	1	-1	-0.1	0.5	-0.1	-0.1
1	0	0	1	0.5	-0.1	-0.1	0.5	0	0	0.5	0	1	+0.1	0.6	-0.1	-0.1
1	0	1	1	0.6	-0.1	-0.1	0.6	0	-0.1	0.5	0	1	+0.1	0.7	-0.1	0
1	1	0	1	0.7	-0.1	0	0.7	-0.1	0	0.6	1	0	0	0.7	-0.1	0
1	1	1	0	0.7	-0.1	0	0.7	-0.1	0	0.6	1	-1	-0.1	0.6	-0.2	-0.1
1	0	0	1	0.6	-0.2	-0.1	0.6	0	0	0.6	1	0	0	0.6	-0.2	-0.1
1	0	1	1	0.6	-0.2	-0.1	0.6	0	-0.1	0.5	0	1	+0.1	0.7	-0.2	0
1	1	0	1	0.7	-0.2	0	0.7	-0.2	0	0.5	0	1	+0.1	0.8	-0.1	0
1	1	1	0	0.8	-0.1	0	0.8	-0.1	0	0.7	1	-1	-0.1	0.7	-0.2	-0.1
1	0	0	1	0.7	-0.2	-0.1	0.7	0	0	0.7	1	0	0	0.7	-0.2	-0.1
1	0	1	1	0.7	-0.2	-0.1	0.7	0	-0.1	0.6	1	0	0	0.7	-0.2	-0.1
1	1	0	1	0.7	-0.2	-0.1	0.7	-0.2	0	0.5	0	1	+0.1	0.8	-0.1	-0.1
1	1	1	0	0.8	-0.1	-0.1	0.8	-0.1	-0.1	0.6	1	-1	-0.1	0.7	-0.2	-0.2
1	0	0	1	0.7	-0.2	-0.2	0.7	0	0	0.7	1	0	0	0.7	-0.2	-0.2
1	0	1	1	0.7	-0.2	-0.2	0.7	0	-0.2	0.5	0	1	+0.1	0.8	-0.2	-0.1
1	**1**	**0**	**1**	**0.8**	**-0.2**	**-0.1**	**0.8**	**-0.2**	**0**	**0.6**	**1**	**0**	**0**	**0.8**	**-0.2**	**-0.1**
1	**1**	**1**	**0**	**0.8**	**-0.2**	**-0.1**	**0.8**	**-0.2**	**-0.1**	**0.5**	**0**	**0**	**0**	**0.8**	**-0.2**	**-0.1**
1	**0**	**0**	**1**	**0.8**	**-0.2**	**-0.1**	**0.8**	**0**	**0**	**0.8**	**1**	**0**	**0**	**0.8**	**-0.2**	**-0.1**
1	**0**	**1**	**1**	**0.8**	**-0.2**	**-0.1**	**0.8**	**0**	**-0.1**	**0.7**	**1**	**0**	**0**	**0.8**	**-0.2**	**-0.1**