

## Solution

- Starting point:  $w=[0\ 0\ 0]$ ,  $b=0$
- Training:

$$\begin{aligned} w^{new} &= w^{old} + e p^T = w^{old} + (t-a)p^T \\ b^{new} &= b^{old} + e \end{aligned}$$

iteration 1:

applying ex.1:  $p_1 = [1\ 0\ 0]^T, t_1=1$

$a = \text{hardlim}([0\ 0\ 0][1\ 0\ 0]^T + 0) = \text{hardlim}(0) = 1$

$e = t_1 - a = 1 - 1 = 0$

$w^{new} = [0\ 0\ 0] + 0[1\ 0\ 0]^T = [0\ 0\ 0]$

$b^{new} = 0 + 0 = 0,$

i.e. no change in  $w$  and  $b$  as  $e=0$

iteration 2:

applying ex.2:  $p_2 = [0\ 1\ 1]^T, t_2=0$

$a = \text{hardlim}([0\ 0\ 0][0\ 1\ 1]^T + 0) = \text{hardlim}(0) = 1$

$e = t_2 - a = 0 - 1 = -1$

$w^{new} = [0\ 0\ 0] + (-1)[0\ 1\ 1]^T = [0\ -1\ -1]$

$b^{new} = 0 + (-1) = -1$

i.e.  $w$  and  $b$  have been updated

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## Solution – cont.

- Similarly:
  - end of iteration 3:  $w^{new}=[1\ 0\ -1], b^{new}=0$
  - end of iteration 4:  $w^{new}=[0\ -1, -2], b^{new}=-1$
  - end of iteration 5: no change
  - end of iteration 6:  $w^{new}=[1\ -1\ -1], b^{new}=0$
  - end of epoch 1
- Check if the stopping criteria is satisfied - each training example is applied to check if it is correctly classified:
  - applying ex.1:  $p_1 = [1\ 0\ 0]^T, t_1=1$
  - $a = \text{hardlim}([1\ -1\ -1][1\ 0\ 0]^T + 0) = \text{hardlim}(0) = 1$  – correct
  - applying ex.2:  $p_2 = [0\ 1\ 1]^T, t_2=0$
  - $a = \text{hardlim}([1\ -1\ -1][0\ 1\ 1]^T + 0) = \text{hardlim}(-2) = 0$  – correct
  - Similarly for ex.3, 4, 5 and 6 – all are correctly classified => end of training
- 1 epoch was needed to train the perceptron. The training set is linearly separable as the perceptron was able to learn to separate it.

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