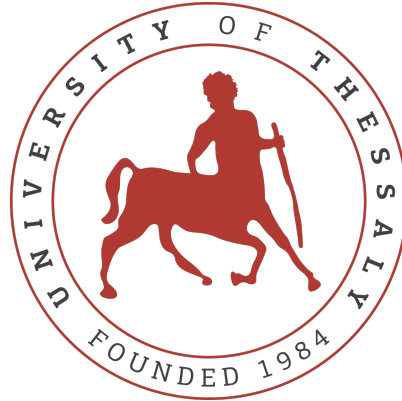


UNIVERSITY OF THESSALY



NEURO-FUZZY COMPUTING

ECE447

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## 2<sup>nd</sup> Problem Set

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## Problem 1

In this exercise we need to find the minimum of the given 2-dimensional function:

$$F(\mathbf{w}) = w_1^2 + w_2^2 + (0.5w_1 + w_2)^2 + (0.5w_1 + w_2)^4 \quad (1)$$

with the Conjugate Gradient (Fletcher-Reeves) method.

Initially, we can conclude that the function  $F(w)$  is not in quadratic form because of the term  $(0.5w_1 + w_2)^4$ . A function is said to be in quadratic form if it can be expressed as a second-degree polynomial where all the terms are either squared terms or cross-products of the variables. The presence of the fourth-degree term  $(0.5w_1 + w_2)^4$  makes this function a higher-degree polynomial, specifically a quartic function with respect to  $(0.5w_1 + w_2)$ , which means it cannot be classified as quadratic.

Also, the independent values in this function are  $w_1, w_2$ , because only with them we can manipulate the  $F(w)$ .

## Problem 3

For the given neural network, we have:

- learning rate  $LR = 1$ ,
- $w^1(0) = -3$ ,  $w^2(0) = -1$ ,
- $b^1(0) = 2$ ,  $b^2(0) = -1$  and
- input/target pair  $\{p = 1, t = 0\}$

### FIRST ITERATION

Step 1: Calculate first layer's output

$$n^1 = w^1 p + b^1 = (-3)(1) + 2 = -1$$

$$a^1 = \text{Swish}(n^1) = \text{Swish}(-1) = \frac{n^1}{1 + e^{-n^1}} = \frac{-1}{1 + e} = -0.2689$$

Step 2: Calculate second layer's output

$$n^2 = w^2 a^1 + b^2 = (-1)(-0.2689) + (-1) = -0.7311$$

$$a^2 = \text{LReLU}(n^2) = \text{LReLU}(-0.7311) = -0.000731$$

Step 3: Calculate error

$$e = t - a^2 = (1 - (-0.000731)) = 1.000731$$

Step 4: Calculate sensitivity on second layer

$$s^2 = -2 \text{LReLU}'(n^2) (t - a^2) = -2(0.001)(1.000731) = -0.002001$$

*LReLU's derivative is 1 for  $x > 0$  and 0.001 for  $x < 0$ .*

Step 5: Calculate sensitivity on first layer using back-propagation

$$s^1 = Swish'(n^1) (W^2)^T s^2 = Swish'(-1) (-1) (-0.002001) = 0.0723 \cdot (-1) \cdot (-0.002001)$$
$$s^1 = 0.000145$$

Step 6: Update weights and biases