第六章:神经网络

第一部分: 计算与证明

Consider a three-layer network for classification with n_H nodes in hidden layer, and c nodes in output layer. The patterns (also say samples) are in d dimensional space. The activation function (or transfer function) for the nodes in the hidden layer is the sigmoid function. Differently, the nodes in the output layer will employ the following softmax operation as their activation function:

$$z_j = \frac{e^{net_j}}{\sum_{m=1}^{c} e^{net_m}}, \quad j = 1, 2, ..., c,$$

where net_i stands for the weighted sum at the j-th node in the output layer.

Please derive the learning rule under the back propagation framework if the criterion function for each sample is the sum of the squared errors, that is (即分析每一层权重的更新方法):

$$J(\mathbf{w}) = \frac{1}{2} \sum_{j=1}^{c} (t_j - z_j)^2$$
,

Where t_j is the known target value for the sample at the j-th node in the output layer.

注意:本题只需要推导出单个样本对权重更新的贡献即可(因为多个样本只是简单地相加)

2. 请对反向传播算法的训练步骤进行总结;结合三层网络给出不超过三个有关权重更新的公式,并用文字描述所述公式的含义;指出哪些因素会对网络的性能产生影响。

第二部分: 计算机编程

本题使用的数据如下:

第一类 10 个样本 (三维空间):

[1.58, 2.32, -5.8], [0.67, 1.58, -4.78], [1.04, 1.01, -3.63], [-1.49, 2.18, -3.39], [-0.41, 1.21, -4.73], [1.39, 3.16, 2.87], [1.20, 1.40, -1.89], [-0.92, 1.44, -3,22], [0.45, 1.33, -4.38],

[-0.76, 0.84, -1.96]

第二类 10 个样本 (三维空间):

[0.21, 0.03, -2.21], [0.37, 0.28, -1.8], [0.18, 1.22, 0.16],

 $[-0.24, \quad 0.93, \quad -1.01], \quad [-1.18, \quad 0.39, \quad -0.39], \quad [0.74, \quad 0.96, \quad -1.16],$

 $[-0.38, \quad 1.94, \quad -0.48], \quad [0.02, \quad 0.72, \quad -0.17], \quad [\ 0.44, \quad 1.31, \quad -0.14],$

[0.46, 1.49, 0.68]

第三类 10 个样本 (三维空间):

[-1.54, 1.17, 0.64], [5.41, 3.45, -1.33], [1.55, 0.99, 2.69], [1.86, 3.19, 1.51], [1.68, 1.79, -0.87], [3.51, -0.22, -1.39], [1.40, -0.44, -0.92], [0.44, 0.83, 1.97], [0.25, 0.68, -0.99], [0.66, -0.45, 0.08]

- 1. 请编写两个通用的三层前向神经网络反向传播算法程序,一个采用批量方式更新权重,另一个采用单样本方式更新权重。其中,隐含层结点的激励函数采用双曲正切函数,输出层的激励函数采用 sigmoid 函数。目标函数采用平方误差准则函数。
- 2. 请利用上面的数据验证你写的程序,分析如下几点:
 - (a) 隐含层不同结点数目对训练精度的影响;
 - (b) 观察不同的梯度更新步长对训练的影响,并给出一些描述或解释;
 - (c) 在网络结构固定的情况下,绘制出目标函数随着迭代步数增加的变化曲线。