Artificial Neural Networks

In class activities

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Activities

Single-layer perceptron neural network

In a chemical processing plant, a critical valve is controlled based on three parameters: temperature, pressure, and reactant concentration, all within normalized ranges. Each parameter is represented as a binary input: 1 if the parameter is within the desired range, indicating favorable conditions for opening the valve, and 0 if it is outside the range, indicating unfavorable conditions. The decision to open the valve depends on these inputs to ensure safe and efficient operation.

- Scenario 1: Low temperature, low pressure, optimal concentration.
- Scenario 2: Optimal temperature, optimal pressure, optimal concentration.
- Scenario 3: Optimal temperature, low pressure, optimal concentration.
- Scenario 4: Low temperature, optimal pressure, optimal concentration.

Table 1: Expected valve position

Temperature	Pressure	Concentration	Valve Opens
0	0	1	0
1	1	1	1
1	0	1	1
0	1	1	0

Design a simple single-layer perceptron using MATLAB to learn this decision-making process based on the input parameters.

Solution

The code for single layer perceptron is in ann_single_layer_perceptron.mlx.

ANN modeling of Crystallization

To control the average crystal size in a crystallization process, it is essential to account for its dependence on two measurable variables:

1. Mother liquor temperature T
2. Mother liquor density ρ

Since average crystal size cannot be directly measured and requires offline laboratory analysis, there are inherent delays in controlling the crystallizer.

To predict crystal size using temperature T and density ρ, consider the following:

1. Input transfer functions
    a. Feed flow rate (U_1)

$$U_1(s) = \frac{1}{s+1} \tag{1}$$

    b. Stirrer Speed (U_2)

$$U_2(s) = \frac{1}{2s+1} \tag{2}$$

2. Process Transfer functions
    a. Temperature (X_1) is influenced by U_1

$$X_1(s) = \left(\frac{2}{3s+1} + \frac{-0.2}{2s^2+1.1s+1}\right) e^{-s} \tag{3}$$

    b. Density (X_2) is influenced by U_2

$$X_2(s) = \frac{e^{-s}}{4s^2+3s+1} \tag{4}$$

3. Dependency of average crystal size d_{avg} (Y) on temperature and density is given by

$$d_{avg} = 10 + (0.8T + 1.3\rho + 1.1T^2 - 1.9\rho^2 + 0.6T\rho) \tag{5}$$

Develop an Artificial Neural Network (ANN) model to predict the average crystal size in a crystallization process based on measured temperature and density, which are influenced by feed flow rate and stirrer speed.

Solution

- Crystallizer model for training
- Crystallizer model control