Artificial Neural Networks

In class activities

Ranjeet Utikar

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# 1. Activities

## 1.1 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.

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.

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|  Solution |
| The code for single layer perceptron is in [ann\_single\_layer\_perceptron.mlx](./ann_single_layer_perceptron.mlx). |

## 1.2 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
	1. Feed flow rate (U1)

$$U\_{1}\left(s\right)=\frac{1}{s+1}  \left(1\right)$$

* 1. Stirrer Speed (U2)

$$U\_{2}\left(s\right)=\frac{1}{2s+1}  \left(2\right)$$

1. Process Transfer functions
	1. Temperature (X1) is influenced by U1

$$X\_{1}\left(s\right)=\left(\frac{2}{3s+1}+\frac{−0.2}{2s^{2}+1.1s+1}\right)e^{−s}  \left(3\right)$$

* 1. Density (X2) is influenced by U2

$$X\_{2}\left(s\right)=\frac{e^{−s}}{4s^{2}+3s+1}  \left(4\right)$$

1. Dependency of average crystal size davg (Y) on temperature and density is given by

$$d\_{avg}=10+\left(0.8T+1.3ρ+1.1T^{2}−1.9ρ^{2}+0.6Tρ\right)  \left(5\right)$$

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.

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|  Solution |
| * [Crystallizer model for training](./ann_crystallizer_model_for_training.slx)
* [Crystallizer model control](./ann_crystallizer_model_control.slx)
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