

INDIVIDUAL TASK (MODULE 2)

Equations of all models

Introduction

This topic discusses Activation Dynamics and Neural Network Models used in Artificial Neural Networks (ANN) to mathematically represent how neuron activations and synaptic weights change over time. These models are formulated using differential equations and are inspired by the functioning of biological neurons. They describe key phenomena such as decay, excitation, inhibition, feedback, associative memory, shunting behavior, and synaptic adaptation. Such mathematical formulations are essential for understanding Hopfield networks, associative memory systems, shunting models, and competitive neural networks.

Equations

1) Hopfield Model

Hopfield Model

The continuous Hopfield network is represented as:

$$\frac{dx_i}{dt} = -x_i + \sum_{j=1}^n w_{ij} f(x_j) + I_i$$

2) Passive Decay Model

$$\frac{dx}{dt} = -Ax$$

3. Synaptic Dynamics

$$\frac{dw_{ij}}{dt} = \eta x_i x_j$$

4) Activation Dynamics (General Form)

$$\frac{dx_i}{dt} = -Ax_i + \sum_j w_{ij} x_j + I_i$$

5) Shunting Activation Model

$$\frac{dx_i}{dt} = -Ax_i + (B - x_i)E_i - (x_i - C)I_i$$

Steady State Solution

At steady state, $\frac{dx_i}{dt} = 0$.

6) Heteroassociative Network

Layer-1

$$\frac{dx_i}{dt} = -x_i + \sum_j w_{ij} y_j$$

Layer-2

$$\frac{dy_j}{dt} = -y_j + \sum_i w_{ji} x_i$$

7) Additive Autoassociative Model

$$\frac{dx_i}{dt} = -x_i + \sum_j w_{ij} x_j$$

8) Perkel Model

$$\frac{dx_i}{dt} = -Ax_i + \sum_j w_{ij} f(x_j)$$

9) Modified Passive Decay Model

$$\frac{dx}{dt} = -Ax + I$$

10) Zero Resting Potential with External Input

$$\frac{dx}{dt} = -Ax + I$$

Steady State Value

$$x = \frac{I}{A}$$

11) Nonzero Resting Potential

$$\frac{dx}{dt} = -A(x - x_0)$$

Terms Explanation:

- x_0 = Resting activation value

Steady State Value

$$x = x_0$$

12) Inhibitory Feedback & External Input

$$\frac{dx_i}{dt} = -x_i + \sum_j w_{ij} x_j - \sum_k v_{ik} x_k + I_i$$

13) On-Center Off-Surround Configuration

$$\frac{dx_i}{dt} = -x_i + w_{ii}x_i - \sum_{j \neq i} w_{ij} x_j$$

14) Shunting Activation Model with Feedback

$$\frac{dx_i}{dt} = -Ax_i + (B - x_i) \sum_j w_{ij} f(x_j) - (x_i - C) \sum_k v_{ik} f(x_k)$$

15) Excitatory Term

$$E_i = \sum_j w_{ij} x_j$$

16) Inhibitory Term

$$I_i = \sum_j v_{ij} x_j$$

17) Shunting Activation Model with Lower Limit

$$\frac{dx_i}{dt} = -Ax_i + (B - x_i)E_i - (x_i - C)I_i$$