Graph Neural Network
Lecture 3

Overview

What is a Graph Convolutional Network (GCN)?

- A type of Graph Neural Network (GNN) designed for graph-structured data.
- Extends the concept of convolutional neural networks (CNNs) to graphs.
- Captures local graph structure and node features.

Why GCNs?

- **Graph-Structured Data**: Many real-world problems involve graphs (e.g., social networks, molecular structures).
- **Node-Level Tasks**: Node classification, link prediction.
- **Graph-Level Tasks**: Graph classification, clustering.

The GCN layer is defined as:

$$H^{(l+1)} = \sigma\left(\tilde{D}^{-\frac{1}{2}}\tilde{A}\tilde{D}^{-\frac{1}{2}}H^{(l)}W^{(l)}\right)$$

- $\tilde{A} = A + I$: Adjacency matrix with self-loops.
- $\tilde{D}$: Degree matrix of $\tilde{A}$.
- $H^{(l)}$: Node features at layer l.
- $W^{(l)}$: Learnable weight matrix.
- σ: Activation function (e.g., ReLU).

Intuition Behind GCN

- **Normalization**: $\tilde{D}^{-\frac{1}{2}}\tilde{A}\tilde{D}^{-\frac{1}{2}}$ ensures normalized aggregation.
- **Feature Propagation**: Each node aggregates features from its neighbors.
- **Nonlinearity**: Activation function introduces nonlinearity.