

Unsupervised Learning Neural Networks

Introduction

- **Supervised Learning:** trained with labeled data
- **Unsupervised Learning:** trained with unlabeled data
- **Goal:** Discover hidden patterns, groupings, or structures
- **Common tasks:** Clustering, Dimensionality Reduction, Feature Extraction

Types of Neural Networks for Unsupervised Learning

Autoencoders

- **Encoder** compresses input into latent representation
- **Decoder** reconstructs input from latent code
- **Applications:** Dimensionality reduction, anomaly detection, denoising, Variational Autoencoders

Self-Organizing Maps (SOMs)

- Maps high-dimensional data to 2D grid of neurons
- Each neuron represents similar inputs
- **Applications:** Clustering, visualization, exploratory data analysis

Restricted Boltzmann Machines (RBMs)

- Neural networks that learn probability distributions
- **Layers:** Visible (input) and Hidden (latent)
- **Applications:** Collaborative filtering, feature learning

Generative Adversarial Networks (GANs)

- Consist of Generator and Discriminator networks
- Generator learns to create realistic samples
- Discriminator distinguishes real vs fake
- **Applications:** Image synthesis, data augmentation, style transfer

Hebbian Learning Networks

- Inspired by neuroscience: 'neurons that fire together, wire together'
- Weights updated based on correlation of activations
- **Applications:** Associative memory, feature extraction

Techniques in Unsupervised Neural Learning

- ❑ **Clustering** → Grouping similar data points together without labels.
- ❑ **Dimensionality Reduction** → Compressing high-dimensional data into fewer meaningful features.

Techniques in Unsupervised Neural Learning

- **Density Estimation** → Learning the probability distribution of the data.
- **Manifold Learning** → Finding the lower-dimensional surface (manifold) on which high-dimensional data actually lies.

Real-World Applications

- Customer segmentation
- Fraud/anomaly detection
- Recommendation systems
- Medical imaging
- NLP (embeddings, self-supervised learning)
- Speech recognition

Advantages & Challenges

Advantages:

- Leverages massive unlabeled datasets
- Discovers hidden patterns
- Enables feature learning

Challenges:

- Harder to evaluate (no labels)
- Risk of meaningless representations
- Computationally expensive