

UNIT 5

NEURODYNAMICS

CONTENTS

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- Neuro Dynamical Models
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- Restricted Boltzmann Machines (architecture, learning, applications)

Introduction to Neurodynamics

- Neurodynamics studies how neural activity evolves over time.
- Applies dynamical systems theory to understand brain function.
- Key in modeling memory, perception, and decision-making.
- Neural activity can be modeled as a dynamical system, where the state of neurons evolves according to differential equations.
- Stability analysis helps determine whether the system converges to equilibrium or diverges.

Equilibrium States & Stability

- **Stability:** determines if system returns to equilibrium after perturbation.
- *Stable equilibrium:* small perturbations return the system to the state.
- *Unstable equilibrium:* small perturbations grow, leading the system away. These are crucial for understanding how the brain maintains consistent activity patterns.

Attractors in Neural Systems

- Point Attractors: Stable fixed points (e.g., memory states).
- Limit Cycles: Oscillatory patterns (e.g., circadian rhythms).
- Chaotic Attractors: Complex, bounded dynamics.
- Model cognitive states and transitions.

Neuro Dynamical Models

- Use mathematical models to simulate neural behavior.
- Capture temporal evolution of neural states.
- Applications: memory, pattern recognition, decision-making

Manipulation of Attractors

- Recurrent networks allow dynamic switching between attractors.
- Model attention, working memory, and cognitive control.
- Neuromodulation can reshape attractor landscapes.

Hopfield Networks

- Recurrent network with symmetric weights.
- Uses energy minimization to store patterns.
- Functions as associative memory.
- Limitations: low capacity, spurious states

Restricted Boltzmann Machines (RBMs)

- Stochastic neural network with visible and hidden layers.
- Learns probability distributions via contrastive divergence.
- Used in deep learning and feature extraction.

Comparison: Hopfield vs RBM

- *Hopfield: Deterministic, associative memory, low capacity.*
- RBM: Stochastic, generative model, deep learning applications.
- Hopfield uses energy minimization; RBM uses probabilistic sampling.

Conclusion

- Neurodynamics bridges neuroscience and AI.
- Attractors model memory, perception, and cognition.
- Hopfield and RBMs are foundational models in neural computation.



Thank You..