1. Large Scale Brain Area Functional Organization

Summary of Part I: Basic Mechanisms.

2. General Functions of Cortical Lobes, Subcortical Areas.
3. Functional Tradeoffs.
4. General Problems.

2. Summary of Part I: Basic Mechanisms

1. Biological realism
2. Distributed Representations
3. Inhibitory Competition
4. Bidirectional Activation Propagation
5. Error–driven Learning
6. Hebbian Learning

3. Structural Principles

- Hierarchical sequence of transformations.
- Specialized pathways.
- Intra-pathway interactions.
- Higher-level association areas.
- Large-scale distributed representation.

4. Dedicated & Content-Specific

Neurons are dedicated to specific content (i.e., they are tuned to detect specific things).

Brain is not a general-purpose CPU.

Tradeoff between specificity & knowledge-dependency vs generality & flexibility.

Traditional symbolic AI fails because it lacks “common sense”.

Time flies like an arrow.
Fruit flies like an apple.

Challenge: to build flexibility from neurons.
Dynamic Principles

Basic mechanisms:
- Multiple constraint satisfaction (MCS).
- Attractors (amplification, bootstrapping, etc.)
- Inhibitory competition.

Cognitive implications:
- *Internal context* affects MCS, control.
- Mutual support produces *active memory*.
- Inhibition leads to *attention*.

Cortical Lobes

General Functions of the Cortical Lobes

- Frontal
  - planning, control
- Parietal
  - motor, somatic, space, action
- Temporal
  - auditory, language, vision
- Occipital
  - vision

Other Areas

Limbic system:
- Hippocampus (rapid learning).
- Cingulate cortex (response selection).
- Amygdala (emotions).

Others:
- Thalamus (sensory input, attention).
- Midbrain neuromods: VTA - dopamine.
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Functional Tradeoffs: Slow vs Fast Learning

Learning must be slow to capture (statistical) structure of environment (averaging).

But you also have to be able to learn rapidly.

*Tradeoff* solved by two systems: cortex learns slowly, hippocampus learns rapidly.

Functional Tradeoffs: Active Memory vs Overlapping Distributed Representations

Overlapping distrib reps useful for capturing info about world.

But overlap/interconnectivity cause spread, not useful for maintaining info over time.

*Tradeoff* solved by two systems: PC has overlapping distributed representations, FC is isolated for maintenance.

FC important for *control* via maintained activations.
12 A Cognitive Architecture

13 Large Scale Brain Area Functional Organization

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14 General Problems

But first:

- Don’t throw the baby out w/ the bathwater!
- Nobody’s perfect!
The Binding Problem

Potential solutions:

- Attention
- Encode conjunctions
- Dynamics (oscillations)
- Nobody’s perfect...

Other General Problems

- Representing multiple instances of the same thing (attention + counting, location)
- Comparing reps (overlap – multiple digits, settling in shared weights – goodness, PMC-PFC)
- Nobody’s perfect...

Recursion and Subroutine-like processing

- In middle of processing, need to perform same processing (recursion) or different processing (subroutine)
- Easy in standard serial computer (store current state, call subroutine w/appropriate arguments)
- Harder when data and processing not separated!
- HCMP, PFC
- Nobody’s perfect...
  The mouse the cat the dog bit chased squeaked.

Generalization

- How to recognize new inputs given dedicated, specialized reps?
- Distributed reps
- Abstraction
- Nobody’s perfect...
- Baby-bathwater...