Orientation Columns combine with Ocular Dominance Columns: Hypercolumns!
Orientation Tuning Function of a Cortical Cell

System Overview:
How cortical simple cells get their orientation tuning
Selective Adaptation: The Psychologist’s Electrode

- Method of Adaptation: The diminishing response of a sense organ to a sustained stimulus
Selective Adaptation: The Psychologist’s Electrode

- **Selective Adaptation**: Evidence that human visual system contains neurons selective for
  - orientation
  - spatial frequency
Orientation

Spatial Frequency
Selectivity Adaptation

- Adaptation experiments provide strong evidence that orientation and spatial frequency are coded by neurons somewhere in the human visual system
  - Cats, Monkeys: Striate cortex, not in retina or LGN
  - Humans operate the same way as cats and monkeys with respect to selective adaptation

Selective Adaptation

- Spatial frequency channels
- Why would the visual system use spatial frequency filters to analyze images?
  - Different spatial frequencies emphasize different types of information
Defining and Separating Different Brain Areas

- Brain areas can be differentiated according to 4 main criteria:
  - **Function (physiology)**
    - Neurons in different parts of the brain are responsive to different aspects of the stimulus (= do different things).
  - **Architecture**
    - Microanatomy can differ widely across brain areas
    - For example, V1 is also referred to as "striate cortex" because it has a series of stripes that run parallel to the surface; these stripes end abruptly at the end of V1.
  - **Connections**
    - Different areas feed forward and also receive backward-reaching connections from distinct areas.
  - **Topography (e.g., retinotopy)**
    - Each distinct visual area has its own retinotopic map.

*Remember ‘FACT’ as a mnemonic*
Secondary Visual Areas

- There are approximately 30 visual areas after V1
  - The functional specialization hypothesis drives much of the research about these areas
  - Some areas seem specialized for processing a certain aspect of visual information (e.g., MT - motion, V4 - color (?))
Secondary Visual Areas

• Cortical areas dedicated to vision are densely interconnected, and can seem quite confusing at first glance.

Secondary Visual Areas

• However, a more general organization is evident in a pair of parallel pathways:
  – **What** pathway
    • Temporal lobe; recognition of objects
  – **Where** pathway
    • Parietal lobe; motion, spatial orientation, localization
The Human Visual System

- Second level of visual association cortex in parietal lobe
- Dorsal lateral geniculate nucleus
- Thalamus
- Eye
- Optic nerve
- Superior temporal cortex
- Second level of visual association cortex
- Stiate cortex (primary visual cortex)
- Ventral stream
- Extrastriate cortex

Responses to Objects and Location

- Left hemisphere
- Right hemisphere
- Form
- Form and location
- Location

Meyer’s Loop:
Since the lens inverts images, the lower half of the retina sees the upper half of world, and vice versa. Longer loop stems from lower half of retina and dives down into temporal lobe.
Summary of object perception theories….

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Early models of recognition

• Template-matching.
  – Early models of recognition were based on matching the stimulus pattern to a set of stored, pre-defined 'templates'. These models can be expanded by incorporating some pre-processing; that is, rotating the stimulus so that it is upright, scaling it to be of a standard size, etc.
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- **Feature analysis.**
  - Instead of looking for a match to a standard shape, feature analysis emphasizes that what makes an 'A' an A is the letter's unique set of defining features.
Failures of matching-models

- There are several key weaknesses of these early approaches to recognition:
  - 3 dimensions. The template-matching and feature analysis models were designed mostly to recognize alphanumeric characters. However, most real-world human recognition occurs on 3D objects, not 2D symbols.
  - Superficial differences. It's hard for these models to 'extract' the basic similarity of repeated instances of an item while also representing superficial differences (consider handwriting as an example).
Failures of matching-models

- There are several key weaknesses of these early approaches to recognition:
  - Where to start? These models don't have a clear means for breaking up complex input into a series of objects-to-be-identified; instead, they seem to rely on being 'fed' items (e.g., letters) to recognize. That seems utterly unlike human perception.

Building blocks of recognition?

- In order to simulate human recognition in a complex 3D world, more recent models of object recognition have relied on defining constraints (or "primitives") and basic strategies that the visual system might use.
- Marr and Nishihara present a model of recognition, restricted to the set of objects that can be described as generalized cones-- objects with a clear main axis and a constant-shape cross section.
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- 2. Component axes. Then, the axes of each of the smaller sub-portions of the object are identified.
- 3. 3D model match. Finally, a match between the arrangement of components and a stored 3D model description is performed to identify the object.