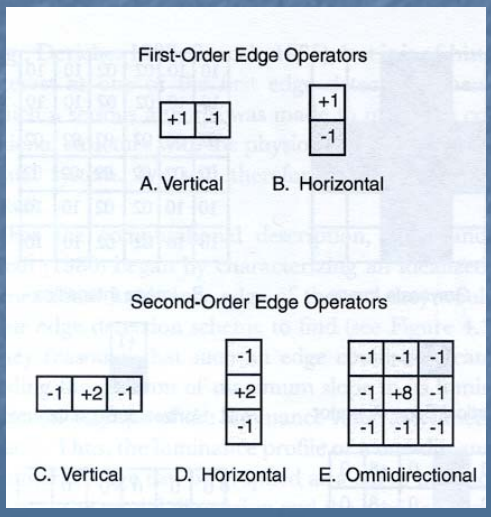
EDGE DETECTION

Edge Detectors



Convolution & Feature Detection

A. Grayscale Image

10	10	02	02	10	10
10	10	02	02	10	10
02	02	02	02	02	02
02	02	02	02	02	02
10	10	02	02	10	10
10	10	02	02	10	10

B. Image Intensities

-1	+1

C. Vertical Edge Operator

+1
-1

D. Horizontal Edge Operator

0	-8	0	+8	0
0	-8	0	+8	0
0	0	0	0	0
0	0	0	0	0
0	-8	0	+8	0
0	-8	0	+8	0

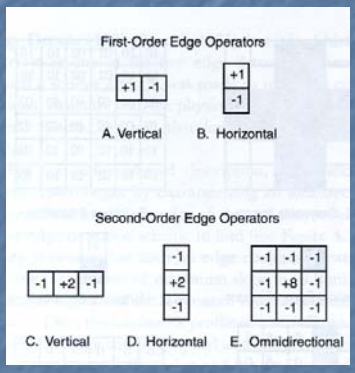
E. Convolution of Image with Vertical Edge Operator

0	0	0	0	0	0
+8	+8	0	0	+8	+8
0	0	0	0	0	0
-8	-8	0	0	-8	-8
0	0	0	0	0	0

F. Convolution of Image with Horizontal Edge Operator

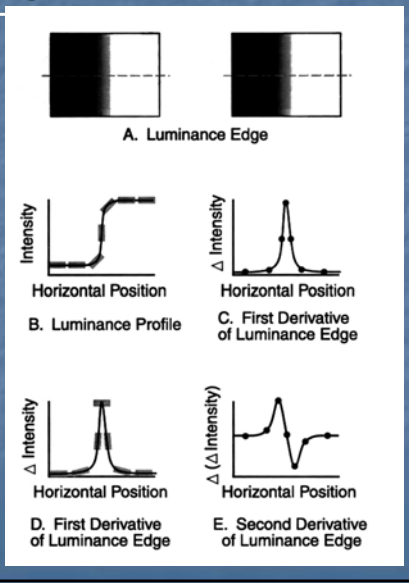
Edge Detectors

- Finds the slope
  - First derivative
  - Direction dependent
  - Need many edge detectors for all orientation
- Second order derivatives
  - Marr Hildreth Method

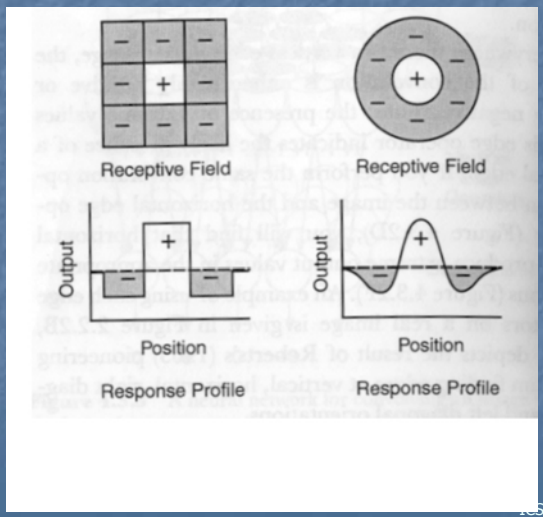


Zero Crossing Curvature

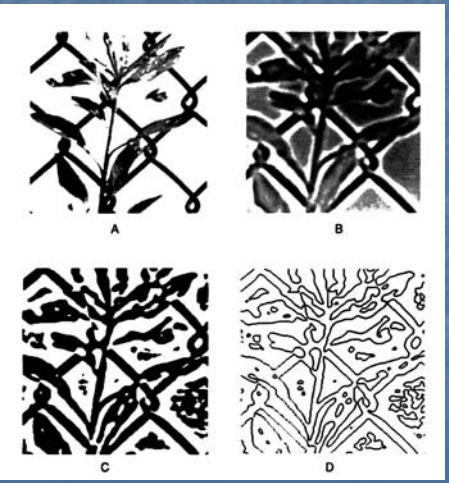
- Maxima of derivative
  - Causes a zero at second derivative
- Symmetric about the zero
- All direction edges can be detected by this zero crossing



Similarity with Receptive Fields



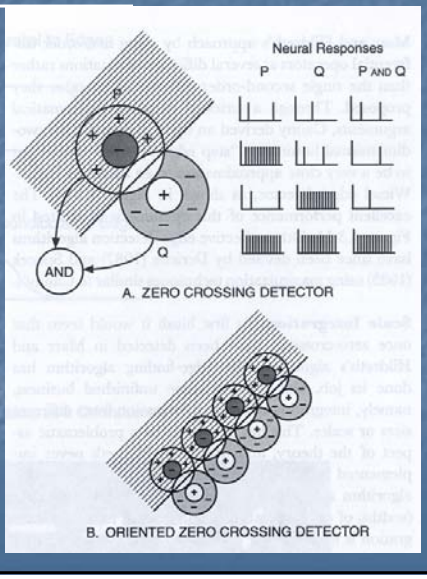
Results of the Algorithm



A. The image
B. Image after convolution
C. Segmented convolved image
D. Edge detected image

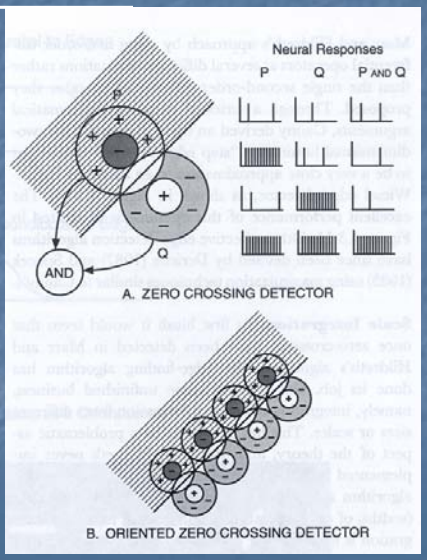
Neural Model

- Three cells
  - Convolution
  - Maxima detection
  - Zero detectors
  - Aligned zero detectors to form edge detectors



Neural Model

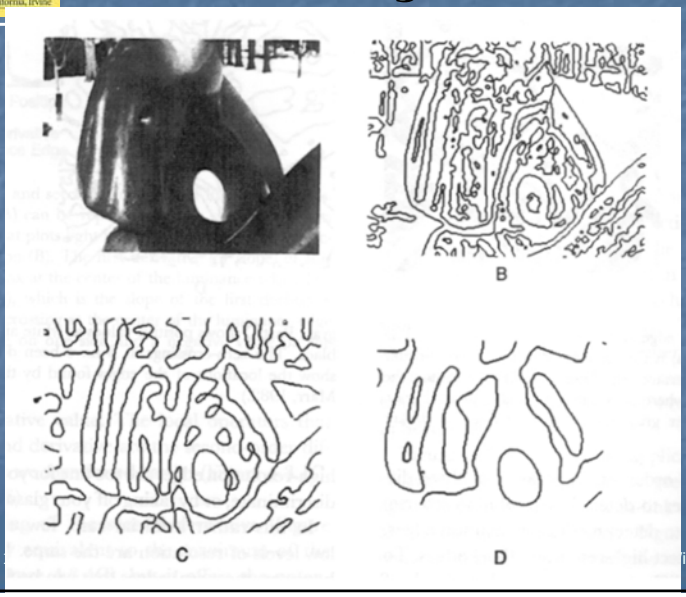
- Three cells
  - Convolution
    - Lateral Inhibition
  - Maxima detection
    - Simple Cortical Cells
  - Zero detectors
    - Complex Cortical Cells
  - Aligned zero detectors to form edge detectors



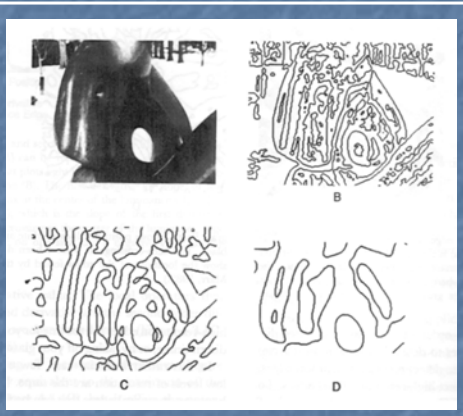
Scaling Problem

- Can occur in different scales or sizes
  - Some have the transition over a broader region
  - Some over a smaller region
  - Edges nevertheless and has to be detected
- Edge detection are done at several levels
  - Image is sub sampled
    - Reduces information content
  - Then edge is detected

Scaling Problem



Scaling Problem



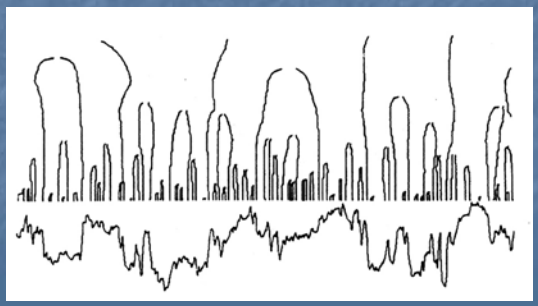
- Edges in coarser level do not disappear in finer levels
- New edges are added
- Coarser level edges are most important
- Advances like a hierarchy

Scale Integration

- Different resolution images in different levels
- How do we know where the coarser level edges are in the finer edge detected image
- Seems very complex yet eye does it easily

Witkin's Explanation

- If we do a continuous subsampling
  - Not possible in digital domain
- Edges are retained, new edges are added with refinement

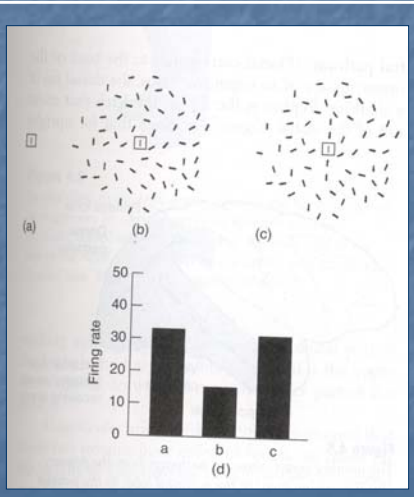


HIGHER-LEVEL VISUAL PROCESSING

Extrastriate Cortex

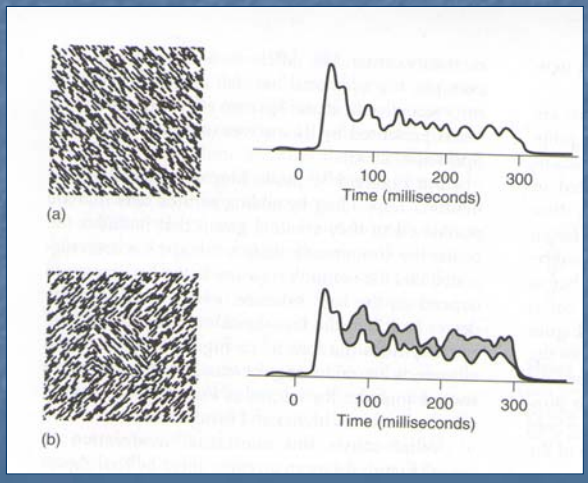
- Hubel and Weisl won Noble prize for their discovery of the cortical cells
- By 1970s, found that other regions of the brain are also involved in vision.
- Cells that respond to far more complex stimuli

Contextual Modulation



- Stimulation can be changed by changing their context
- Salience: Degree to which things stand out

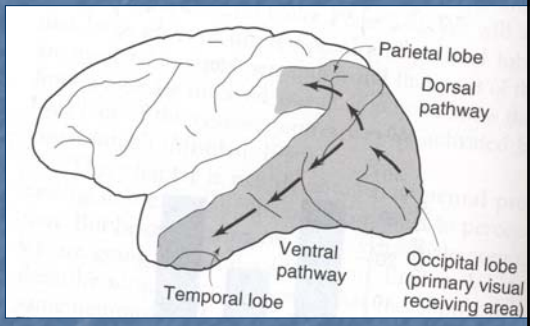
Physiological Explanation



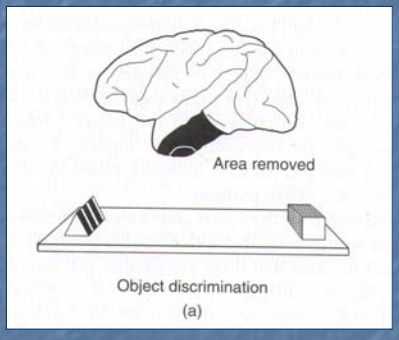
- Notice 80ms initial quiet
  - Time required to process salience
- Related to selective adaptation

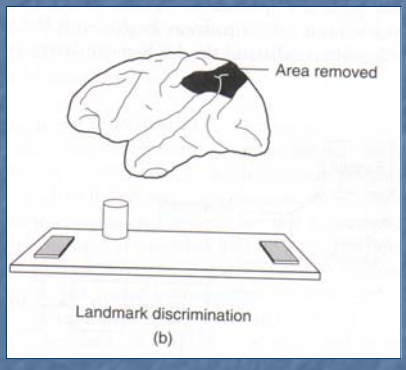
Processing Streams

- Dorsal Pathway
  - Parietal Lobe
  - 'Where'
  - Location and Action
- Ventral Pathway
  - Temporal Lobe
  - 'What'
  - Object Discrimination



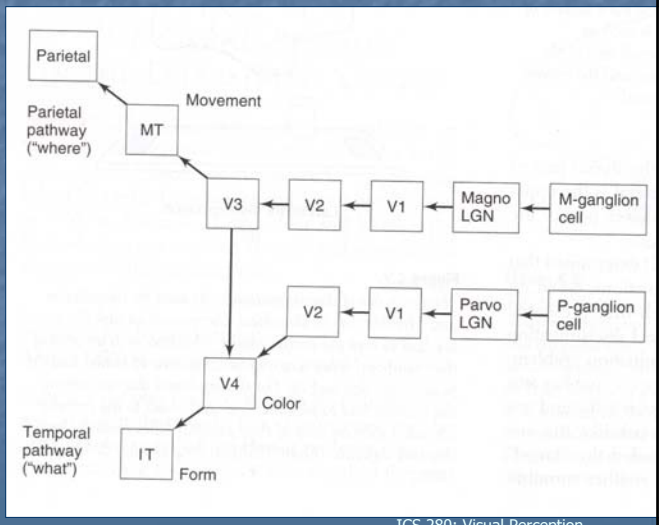
Supporting Experiments





The Whole Pathway

- Parallel Path
- Not independent
- P-cells to ventral
- M-cells to parietal

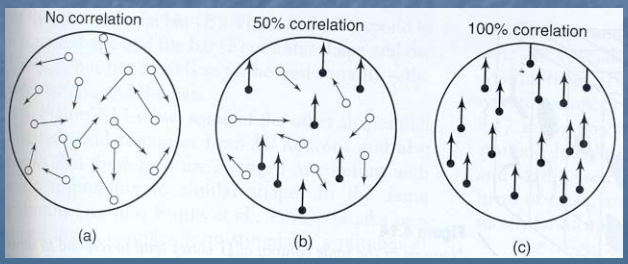


Modular Neurons

- Neurons in MT and IT
- Process very specific information
- Experiment of motion correlation

Experiment with motion correlation

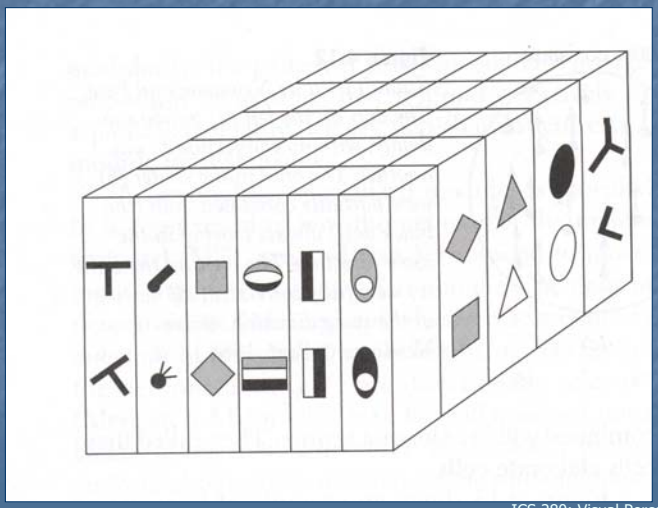
- If MT present, can detect as small as 1-2% correlation
- If MT absent, cannot detect less than 10-20% correlation



Infotemporal cortex

- Primary Cells
  - Respond to simple stimuli
    - Slits, spots, ellipses, squares
- Elaborate Cells
  - Responds to complex stimuli
    - Specific shapes, shapes with color and texture

Hypercolumn Again



Neurons respond to faces

- If a body with face is presented as stimuli, they fire
- When the face is covered with paper, they stop firing
- fMRI research with humans
  - Fusiform face area (FFA) or fusiform gyrus
- Prosopagnosia
  - Due to damage to temporal lobe
  - Fusiform gyrus

The Sensory Code

- Information encoded in the firing of neurons
  - Specificity Coding
    - Every neuron responds to a specific stimuli
  - Distributed Coding
    - Difference in amounts of response in several different neuron creates a pattern that causes identification of specific stimulus
    - To some extend, like number system
    - More number of levels for each neuron, lesser the number of neurons needed for coding

The Sensory Code

- Information encoded in the firing of neurons
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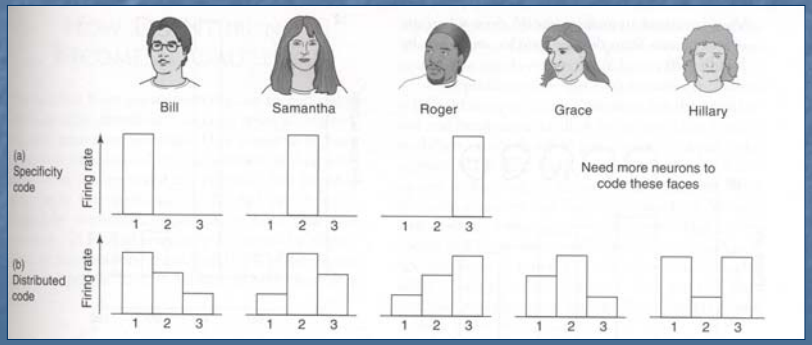
  - Distributed Coding



Neurons in IT for Face Recognition

- Size invariant
- Location invariant
- View invariant
- Size specific
- Location specific
- View specific

Role of Attention

- Selectivity of attention
  - Directs our receptors to stimuli
  - Enhances the perception of stimuli

Inattentional Blindness

- Cannot recognize shape of unattended object when attending to some other visual job
- Experiments of shape presented while performing the task of identifying shorter length

Attentional Blink

- Attentional Blink
  - Inability to attend to a different stimulus within a short period of 500ms
  - Demonstrated by rapid serial visual presentation (RSVP)

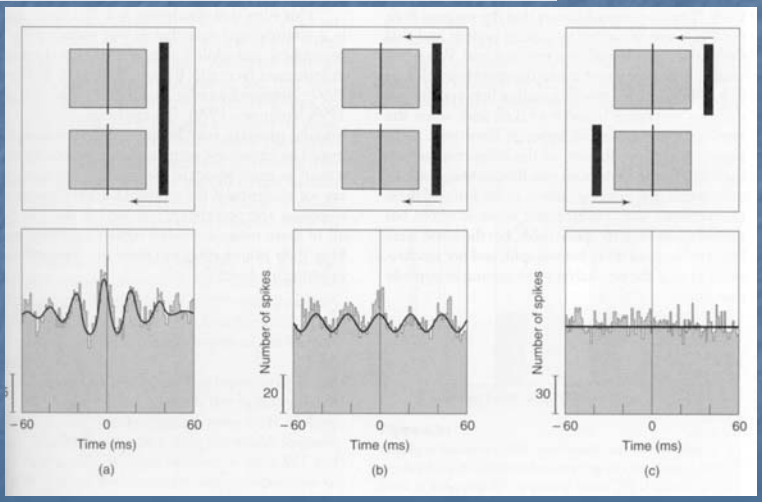
Change Blindness

- Change Blindness
  - Inability to detect unattended changes
  - Even when the stimulus is presented slowly

Binding Problem

- How do we know it is all from the same object
  - Example of a car
- Depends on the synchrony of neuron firing
- If same object, all the different neurons fire synchronously
- Cross correlogram plots of the brain

Cross Coreleograms



Projects in Mind

- Quantification of salience
  - For images
    - Parameters: color, edges, spatial frequency, motion
  - For 3D (More complicated)
    - Parameters: Distance from the viewer, color, geometry, texture, task at hand
- Image and Geometry compression
  - Can we do better than JPEG?
- Rendering
  - Off line processing?
  - Online real time processing?
  - Hierarchical View dependent rendering?