Depth, and Motion in Vision

CMSC 436/636

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Depth Perception

Magnocellular Division

- Discriminates objects from one another
- Characteristics (relative to parvocellular path)
  - color : insensitive to wavelength variations
  - acuity : larger RF centers
  - speed : faster and more transient response
  - contrast : more sensitive to low contrast stimuli
- Observed characteristics of motion perception
  - color-blind: impaired at equiluminance
  - quickness
  - high contrast sensitivity
  - low acuity : impaired at high spatial frequencies

Depth Pathway

- Red and green cones
- Type A retinal ganglion cells
- Magnocellular layers in LGN
- Primary visual cortex
  - disparity tuned neurons (thick stripes in V2)
- Middle Temporal Lobe (MT)

Motor Cues

- Vergence
- Accomodation

Binocular Cues

- Depth cues resulting from two views (one from each eye)
- Include:
    - retinal disparity (stronger for close objects)
    - neurons sensitive to particular disparities

Monocular Cues

- Depth cues available in single eye image
- Include:
  - Occlusion
  - Size
  - Perspective
  - Head-motion parallax
  - Kinetic depth effect (object-motion parallax)

Motion and Interaction

Roles of Motion Processing

- Required for Pattern Vision
- Driving Eye Movements
- Time to Collision
- Expproprioceptive Information
- Perception of Moving Objects
- Depth from Motion
- Encoding 3D Shape
- Image Segmentation

Characteristics of Motion Perception

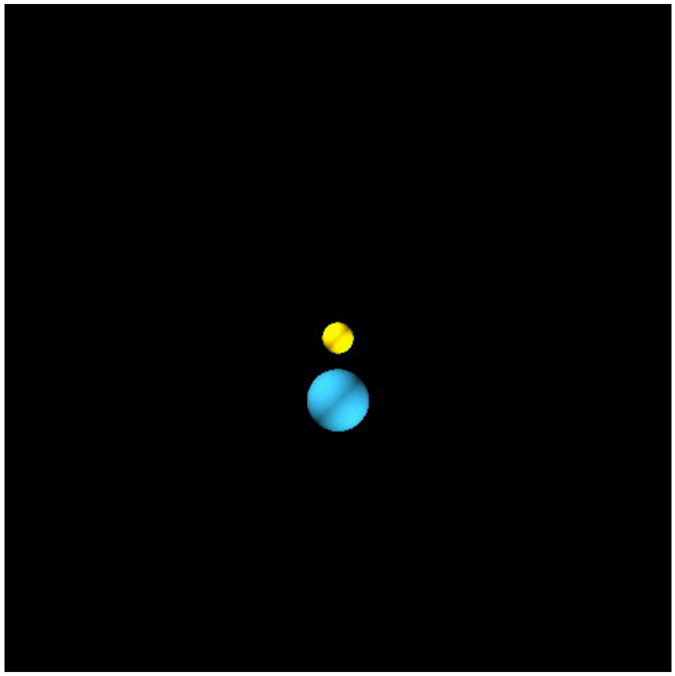
- Fundamental, independent visual process
  - motion aftereffects
  - motion blindness
- Based primarily on brightness
- Ability to interpret structure degrades in periphery
- Spatio-temporal interactions

Motion Pathway

- Red and green cones
- Type A retinal ganglion cells
- Magnocellular layers in LGN
- Area 4B in primary visual cortex
  - direction selectivity
  - velocity selectivity
  - expansion/contraction of visual field
  - global rotation
- Middle temporal lobe

Apparent Motion

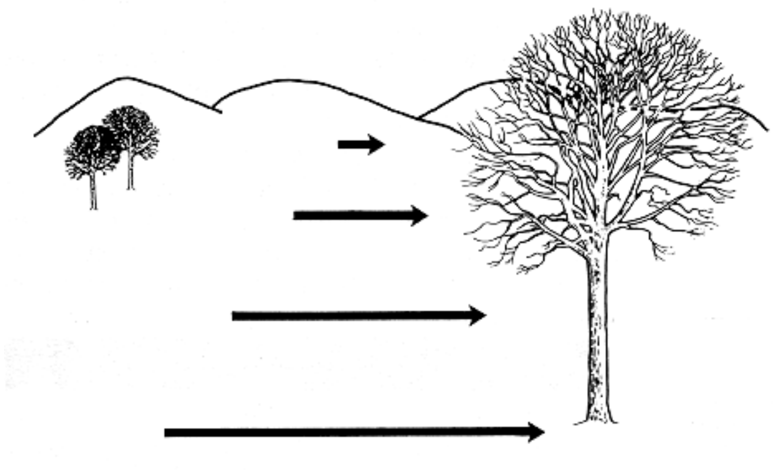
- Def: perception of motion without stimulus continuity (stroboscopic and cine)
- Influences
  - spatial frequency characteristics
  - global field effects
  - number of frames
  - expectations from reality
- Limitations
  - maximum of 300 msec interstimulus interval
  - decreased size constancy (max ~8 Hz)
  - decreased sense of observer motion



Depth from Motion

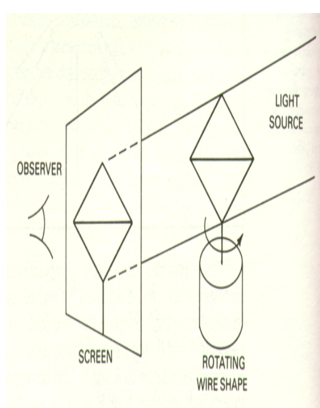
- Motion depth cues
  - head motion parallax
  - kinetic depth effect
  - magnitude of motion indicates relative depth
- Applications
  - indicating relative object positions
  - compensating for lack of other depth cues
- Limits
  - relative, not absolute depth
  - perceived size, perceived depth related

Head Motion Parallax

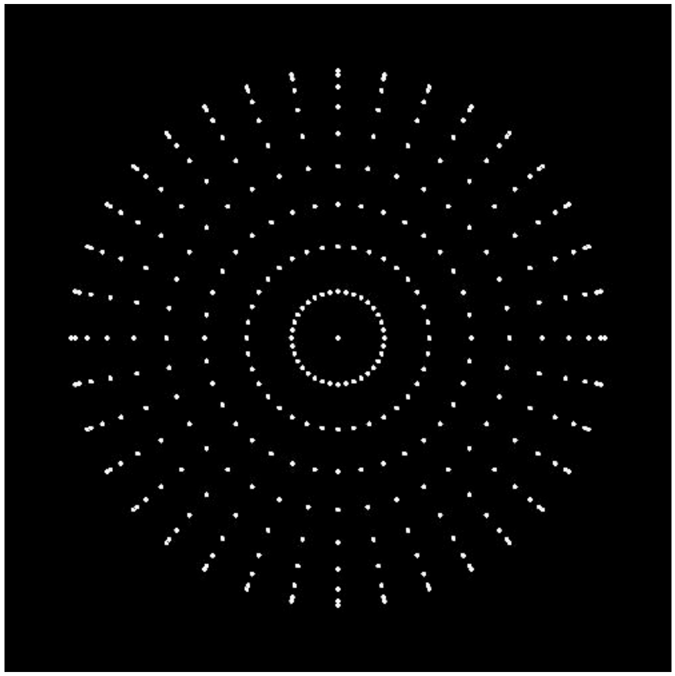


- Bruce and Green ‘90, p. 231.

Kinetic Depth Effect



- Bruce and Green ‘90, pg. 162.



3D Structure from Motion

- Relative motion conveys info about 3D shape
- Rigidity assumption
- Applications
  - understanding of irregular/unfamiliar shapes
  - disambiguation of 2D projections
- Limits
  - 2 frames (large number of structured points)
  - 2-3 points (many frames)
  - 15 arc min (maximum displacement)

Structure from Motion

- Bruce and Green '90, pg. 328.

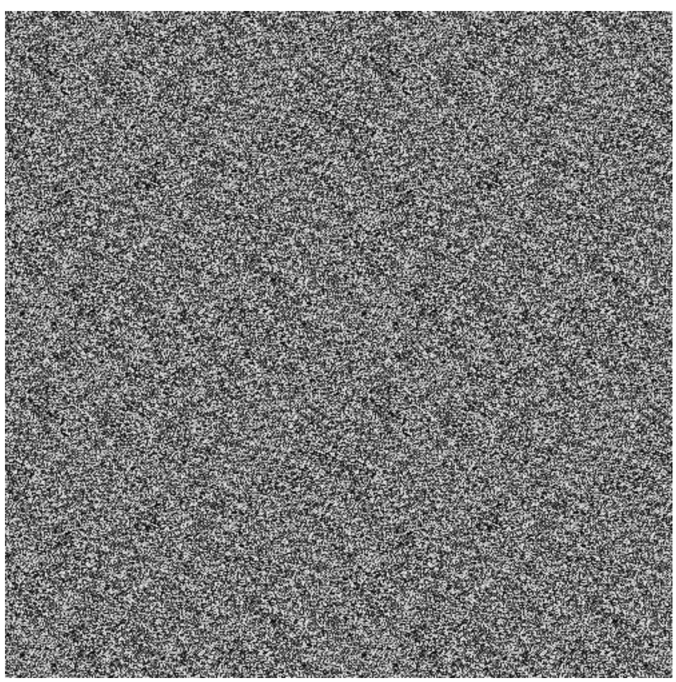


Image Segmentation

- Discontinuities in optical velocity field indicate object boundaries
- Boundaries can be detected on the basis of motion alone
- Applications
  - disambiguation of complex scenes
  - grouping of similar objects

At Equiliminance

- Motion perception of gratings degrades
- Depth perception disappears
- Depth from relative motion disappears
- Shape from relative motion disappears

Interaction vs. Animation

- Exploration vs. Presentation
  - efficiency
  - flexibility
- Active vs. Passive Participation
  - immediacy
  - control
  - development
  - understanding

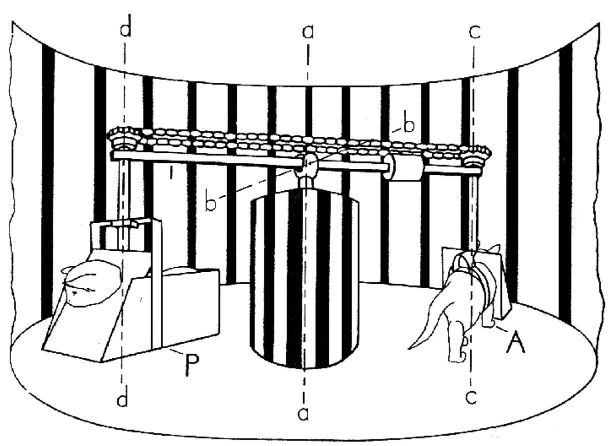
Interactive Control

- Scene
  - viewpoint and direction
  - object position and orientation
- Content
  - variables
  - timestep
- Representation
  - techniques
  - parameters

Experimental Findings

- Control necessary for development
  - Held and Hein ‘63
- Dynamic control improves shape identification
  - van Damme ‘94
  - Rheingans ‘92, ‘93
- Control inproves assembly performance
  - Smets and Overbeeke ‘95
- Differences between types of control
  - Ware and Francke ‘96
  - Pausch, Proffit, Williams ‘97
  - Usoh, et al. ‘99

Kitten Carousel



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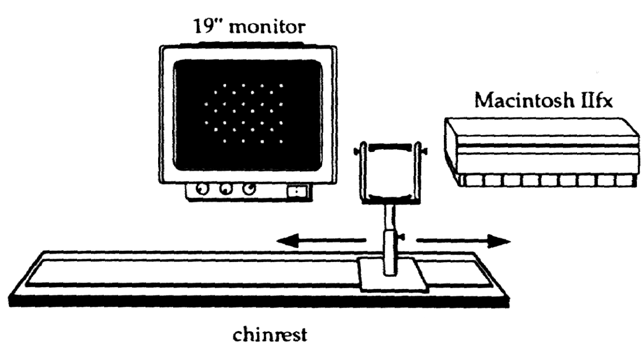
Shape Identification



- van Damme ‘94, p. 18.

Effects of Control

		Control		
		None	Pace	Complete
Change	Jerky	Slide Show	Slide Projector	Interactive
	Smooth	Constant Loop	Multispeed Loop	Dynamic

- Rheingans '92, '93, '97.

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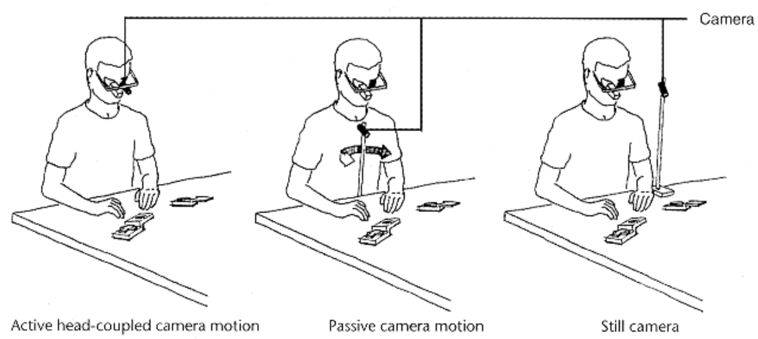
Assembly Performance



- Smets and Overbeeke ‘95, p. 47.

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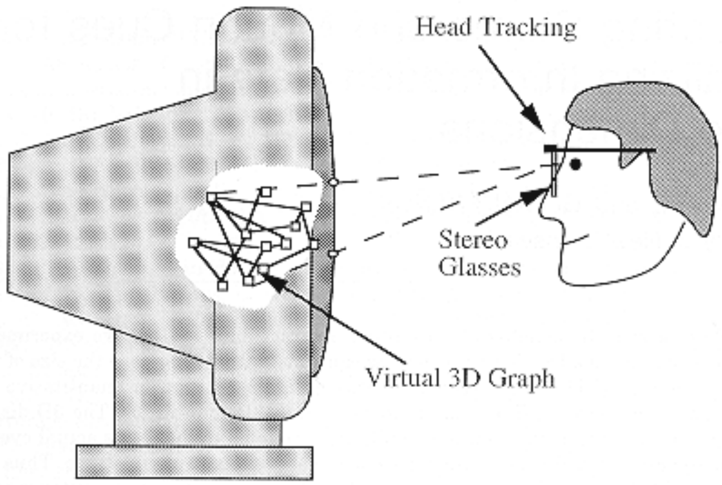
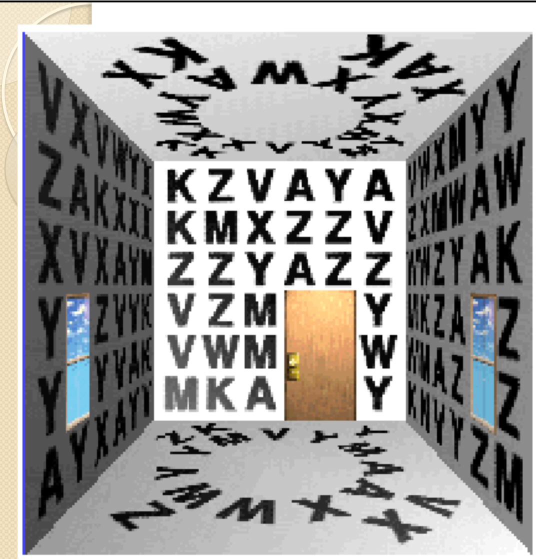
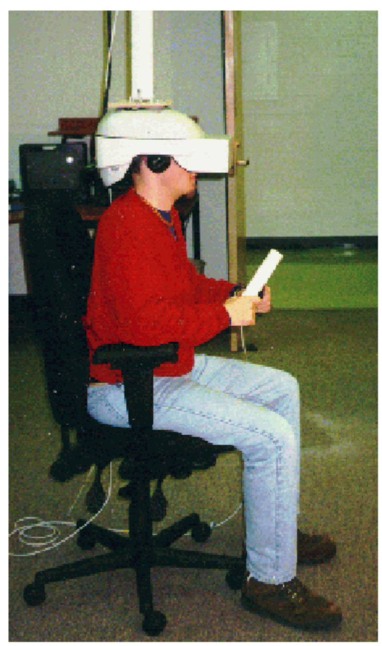
Type of Control

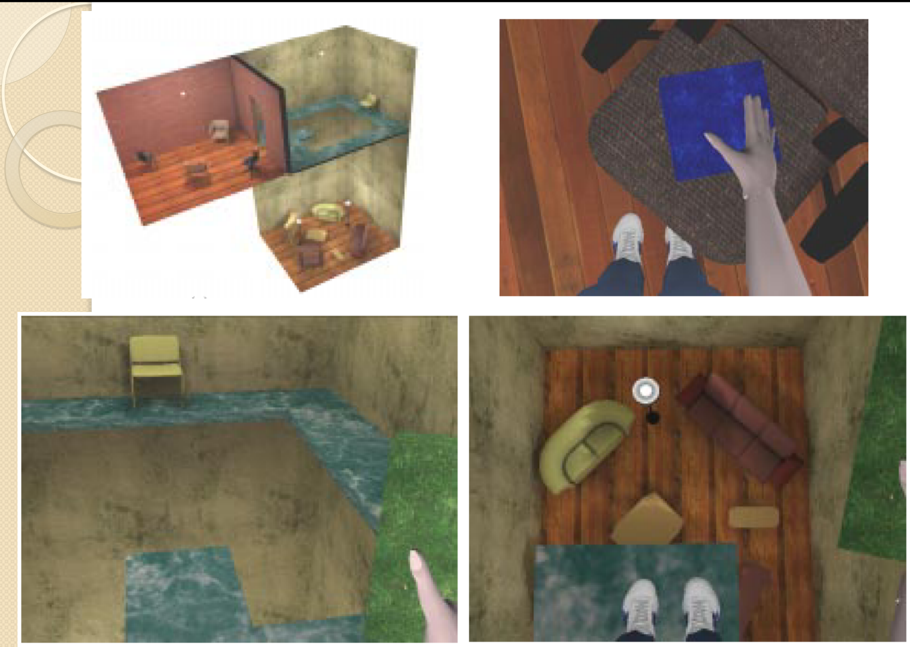


- Ware and Francke '96, p. 122.





Pausch, Proffit, Williams '97



Usoh, Arthur, Whitton, Bastos, Steed, Slater, Brooks ‘99