Motion and Interaction

SIGGRAPH ‘99 Course:
Fundamental Issues of Visual Perception
for Effective Image Generation

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Overview

• Roles of Motion Processing
• Mechanism of Motion Perception
• Using Motion to Represent Information
• Interactive Control
Roles of Motion Processing

- Required for Pattern Vision
- Driving Eye Movements
- Time to Collision
- Exproproceptive 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

**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
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 improves assembly performance
  – Smets and Overbeeke ‘95
• Differences between types of control
  – Ware and Francke ‘96
**Experimental Findings**

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Shape Identification

- van Damme ’94, p. 18.

Effects of Control

<table>
<thead>
<tr>
<th>Change</th>
<th>Control</th>
</tr>
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<tbody>
<tr>
<td>Jerky</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Pace</td>
</tr>
<tr>
<td></td>
<td>Complete</td>
</tr>
<tr>
<td>Smooth</td>
<td>Slide Show</td>
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<tr>
<td></td>
<td>Slide Projector</td>
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<tr>
<td>Smooth</td>
<td>Constant Loop</td>
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<tr>
<td>Smooth</td>
<td>Multispeed Loop</td>
</tr>
<tr>
<td>Smooth</td>
<td>Dynamic</td>
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</tbody>
</table>

- 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.
Avoid

- Moving objects without clear boundaries
- Combining movement (of object or viewpoint) and shape change
- Motion without reference cues
- Mismatched spatial and temporal frequencies
- Temporal aliasing