Realtime 3D Computer Graphics & Virtual Reality

Introduction
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Acknowledgement: Partly based on work by Angel/Bowman/B. Fröhlich and others
3D Computer Graphics is about

- Representation and modeling of three-dimensional objects
- Creation of 3D scenes including lighting
- Rendering of 3D scenes
- Computer Animation
Virtual Reality is about

- 3D Computer graphics
- Real-time simulation & rendering
- Interaction & feedback
- Immersion
- Creation & design of virtual environments
VR can be seen as subfield of CG

also instructive to contrast VR with conventional CG:

<table>
<thead>
<tr>
<th>3D Computer Graphics</th>
<th>Virtual Reality</th>
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<tbody>
<tr>
<td>Purely visual presentation</td>
<td>Multimedia presentation</td>
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<tr>
<td>Presentation can be rendered</td>
<td>Real-time presentation</td>
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<tr>
<td>off-line, time is uncritical</td>
<td>Real-time interaction and simulation</td>
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<td>Static scenes or predefined animations</td>
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<td>2D interaction mouse, keyboard</td>
<td>3D interaction with special input devices + speech</td>
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VR-programming

- To drive advanced virtual reality input devices like
  - 3D mice, spaceball
  - stylus
  - gloves
  - 6DOF trackers (magnetic, gyroscopic, ultrasonic, optical)
  - speech recognition systems
  - haptic devices
  - treadmill-type
  - inertial displays (flight simulators) - full and partial
VR Input devices

- Hardware that allows the user to communicate with the system
- Input device vs. interaction technique
- Same device can be used for various interaction techniques
Input device characteristics

- Discrete / event-based
- Continuous / sampled
- Hybrids
- Miscellaneous input
  - speech
  - locomotion devices
Discrete input devices

- Generate one event at a time
- Event queue
- Examples:
  - buttons
  - keyboards
  - pinch gloves
Continuous input devices

- Produce steady* stream of data
- Sampled at various times by the system for “snapshot” of state
- Examples:
  - trackers
  - data gloves
  - potentiometers
Tracking systems

- Measure position and/or orientation of a sensor
  - 6 degrees of freedom in space
- Most VEs track the head and the hand(s)
- Spatial input devices
- Tracked real objects resembling virtual objects
- Motion capture
Electromagnetic tracker

- **Most common (still)**
- **Transmitter**
  - Creates three orthogonal low-frequency magnetic fields
  - Short range version: < 1m
  - Long range version: < 3m
- **Receiver(s)**
  - Three perpendicular antennas
  - Distance is inferred from the currents induced in the antennas
- **Distortions**
  - Noisy - requires filtering
  - Affected by metal - requires non-linear calibration
- **Wireless versions**
Sensors
100 updates/sec
3 meters range from base unit
Resolution < 2 mm and < .2 degrees

Electronic unit
(2 hours battery life)

Wireless suit (Ascension Technology)
Optical tracker

- “marker”
  - reflects IR light
  - Combined to unique spatial configuration per tracked position
- > 3 IR cameras
- Advantages
  - No interference with metal
  - Low latency
  - High resolution
- Disadvantages
  - Line of sight issues (more cameras help)

6DOF optical tracker by ART
Acoustic Trackers

- Uses ultrasound
- Typical setup for 3 DOF
  - 3 microphones
  - 1 speaker
- Distance is inferred from the travel time for the sound
- Advantages
  - No interference with metal
  - Relatively inexpensive
- Disadvantages
  - Line of sight issues
  - Sensitive to air temperature and certain noises

Logitech Fly Mouse
Inertial trackers

- Intersense IS-300
- Less noise, lag
- Only 3 DOFs (orientation)
- Use gyroscopes and accelerometers
Hybrid Trackers

- For example: Intersense IS-600 / 900
- inertial (orient.)
- acoustic (pos.)
Data Gloves

- Used to track the user’s finger movements
  - for gesture and posture communication
- Almost always used with a tracker sensor mounted on the wrist
- Common types
  - CyberGlove
    - 18 sensors
    - 22 sensors
  - 5DT Glove
    - 5 sensors
    - 16 sensors
Hybrid devices

- Continuous and discrete input
- Examples
  - Button device + tracker
  - Flex & Pinch
  - ring mouse
  - LCD tablet
  - Shape Tape
  - Cubic Mouse
  - Spaceball
Tracked Wands
Props

- Head prop
- Car prop
- ...

Courtesy Hinkley et al.
Mouse Type Devices

- Space Mouse
- Ring Mouse (pictured)
- Fly Mouse
Isometric Devices

- Spaceball
- SpaceOrb (pictured)
  - Potentially tracked
The Cubic Mouse
Cubic Mouse

- First 12 DOF input device
- Tracks position and rotation of rods using potentiometers

- Other shapes and implementations possible
  - Mini Cubic Mouse
  - ...

[Image of a hand holding a Cubic Mouse device]
Shape Tape

Courtesy Balakrishnan et al
More input devices

Cyberglove with haptics

Treadmill types (e.g. bicycles)
Speech Input

- Can complement other modes of interaction
  - multi-modal interaction

- Issues to consider
  - continuous vs. one-time recognition
  - choice and placement of microphone
  - training vs. no training
  - handling of false positive recognition
  - surrounding noise interference
VR-programming

- To drive enhanced virtual reality display setups like
  - responsive workbenches
  - walls
  - head-mounted displays
  - boomes
  - domes
  - caves