

Realtime 3D Computer Graphics & Virtual Reality



Introduction

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Angel/Baumier/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

3D Computer Graphics vs. Virtual Reality

- VR can be seen as subfield of CG
- also instructive to contrast VR with conventional CG:

3D Computer Graphics	Virtual Reality
Purely visual presentation	Multimedia presentation visual, acoustic, haptic
Presentation can be rendered off-line, time is uncritical	Real-time presentation
Static scenes or predefined animations	Real-time interaction and simulation
2D interaction mouse, keyboard	3D interaction with special input devices + speech

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: $< 1\text{m}$
 - Long range version: $< 3\text{m}$
- 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



6DOF Magnetic tracker & DataGlove

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



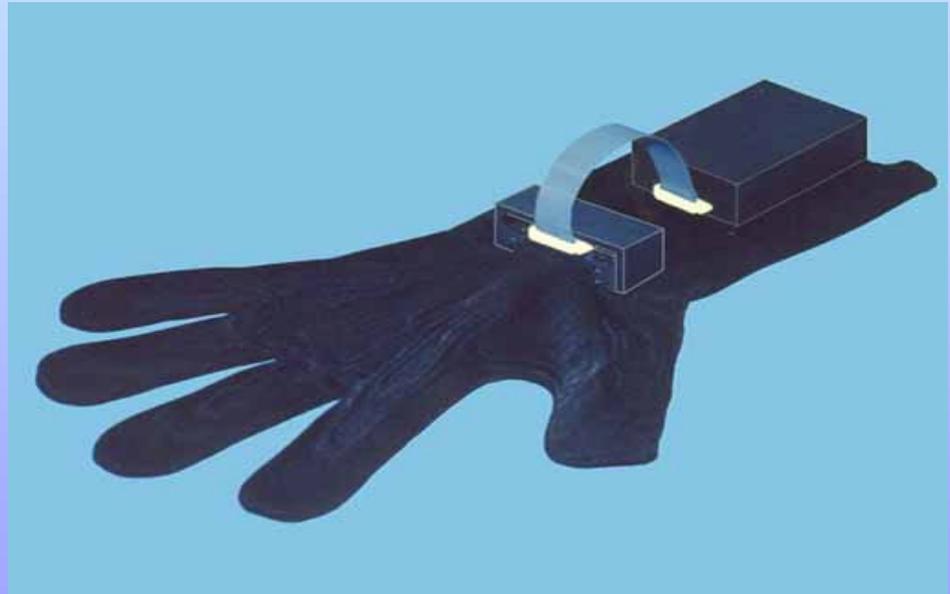
Hybrid Trackers

- 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

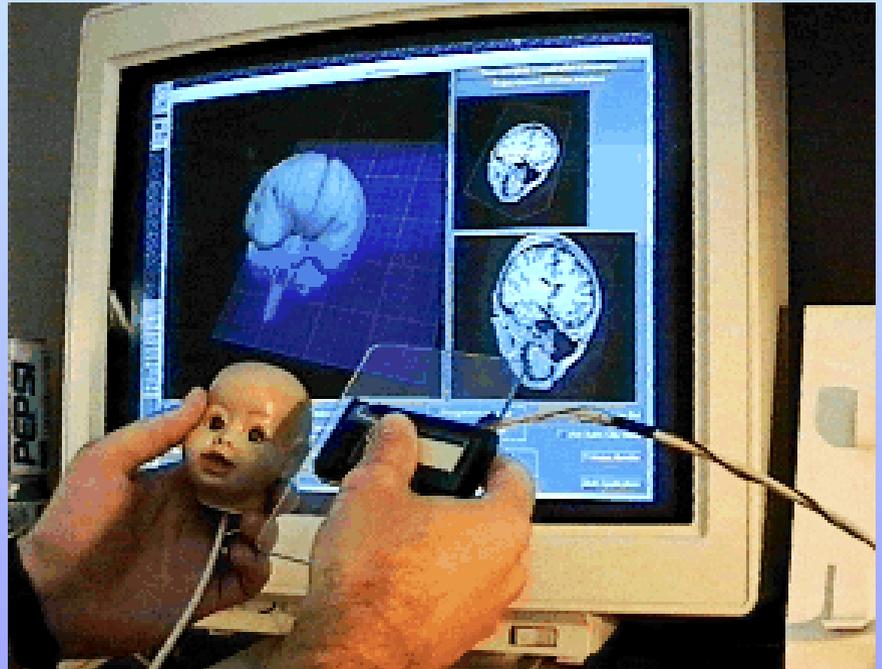


Tracked Wands



Props

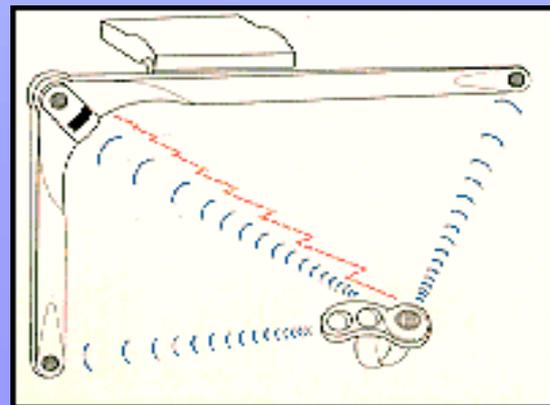
- Head prop
- Car prop
- ...



Courtesy Hinkley et al.

Mouse Type Devices

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

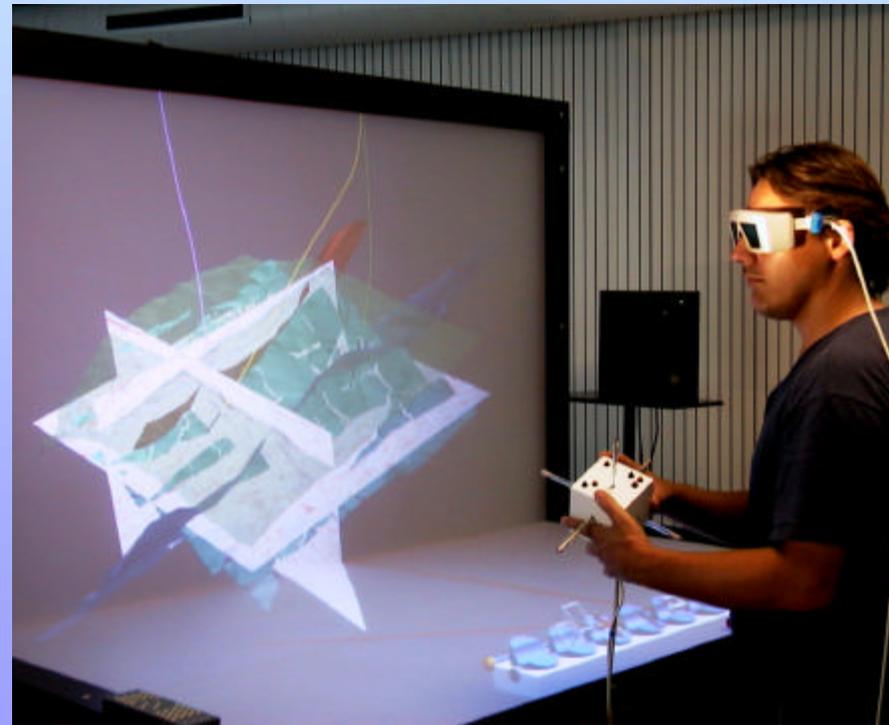
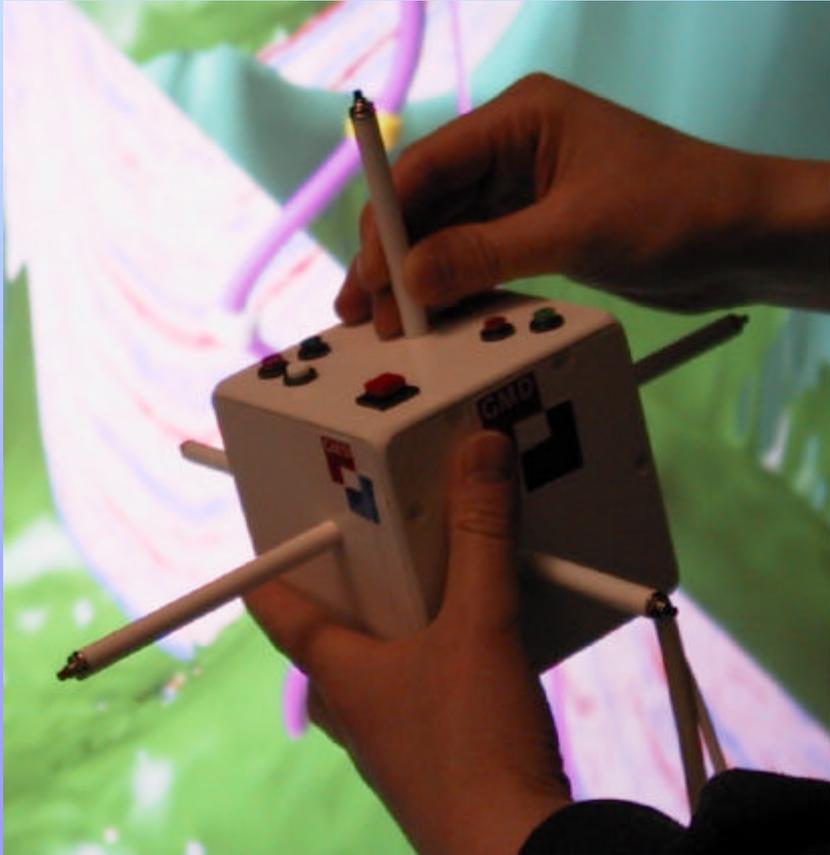


Isometric Devices

- Spaceball
- SpaceOrb (pictured)
 - Potentially tracked

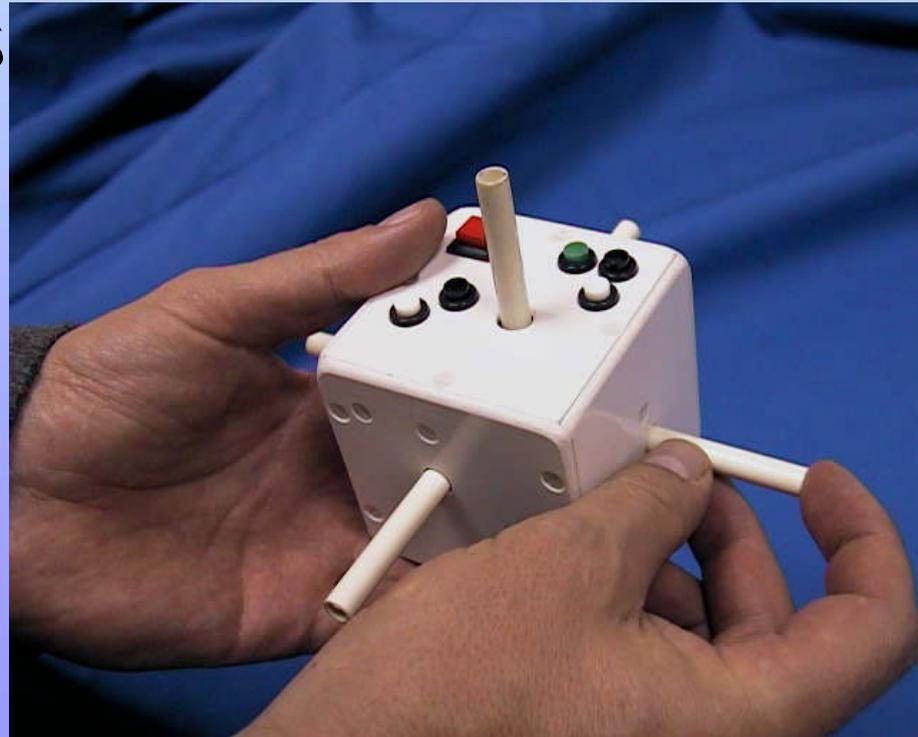


The Cubic Mouse

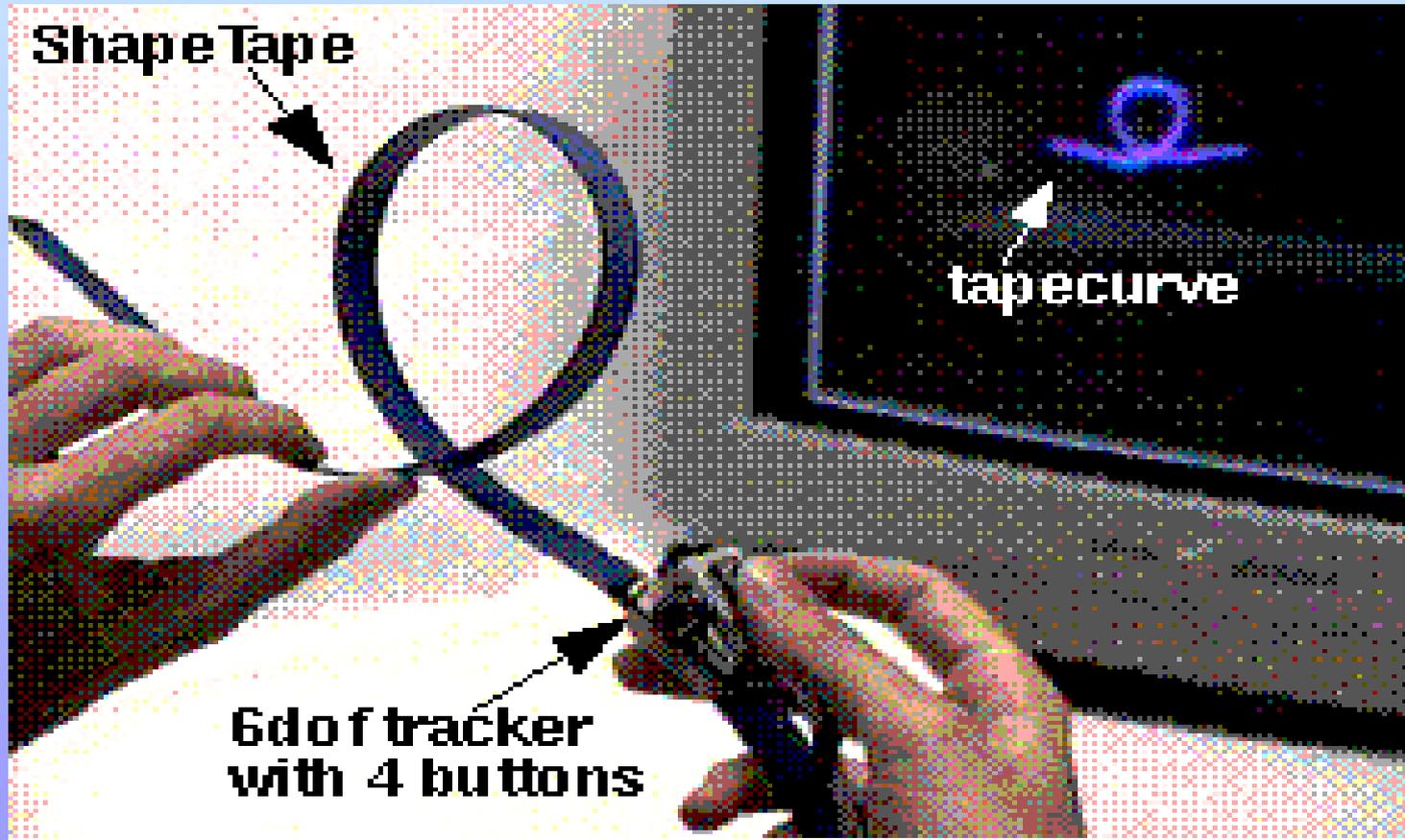


Cubic Mouse

- First 12 DOF input device
- Tracks position and rotation of rods using potentiometers
- Other shapes and implementations possible
 - Mini Cubic Mouse
 - ...



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