VR Software

Class 4

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Audio Output

- Can be divided into two elements:
  - Audio Generation
  - Audio Presentation

Audio Generation

- A variety of audio generation exist:
  - Some uses dedicated hardware to accelerate computations
  - Some uses software to perform calculations
- Can be classified as either
  - tightly coupled
  - Or loosely coupled

Audio Generation

- Tightly coupled with the simulator means that the audio generation is performed in the same host computer
- In this case the Audio Generation subsystem is dedicated to a particular simulator
- The software that control the audio generation subsystem is built into the simulation

Audio Generation

- Loosely Coupled with Protocol means that the Audio Generation system is operating on a host computer different from the one running the simulation
- These audio subsystem can provide services to a variety of simulators, however they are associated with one particular simulator during operation

Audio Generation

- Communications between the simulator and the audio subsystem take place via message passing protocols:
  - Musical Instrument Digital Interface (MIDI) messages
  - SIMNET or DIS Protocol Data (PDUs)
  - High Level Architecture (HLA) transactions
  - Custom message formats
- Physical connectivity between the subsystems is commonly by Ethernet or serial line

Audio Presentation

- The presentation of audio can be achieved either through speakers or headphones
- The method used depends on the design of the physical simulator environment along with the objectives of the simulation

Speakers

- Open field audio presentation
- Unencumbering
- Presents audio to a group of individuals
- Can also be disruptive to other participants or observer
- Speakers provide strong bass presentation and high energy output

Speakers

- Their installations may consist of:
  - single-channel monaural
  - dual-channel stereophonic
  - Multi-channel configurations
- Can be self amplified or powered by an external amplifier/mixer

Headphones

- Close field presentation
- Well suited for environments where the audio is not meant to be heard by anyone other than the participant
- Spatialized audio is generally perceived best when presented over headphones
- Unlike speakers, headphones are encumbering
- This encumbrance can be minimized with the use of wireless transmission

Headphones

- Two configurations:
  - Circumaural (around the ear)

    Effectively eliminates all audio other than that generated by the system
  - Supra-aural (on the ear)

    Allow the participant to hear sounds in addition to those of the audio subsystem

    In-ear (inside the ear) can be considered as supra-aural

Content Representation

- The content of audio consists of sounds generated by:
  - the local entity
  - Remote entities
  - Ambient environmental sounds
  - Other objects

Local Entity Sounds

- The local entity representing the local participant in an exercise is a source of sounds that can be simulated in the virtual environment
- Sounds associated with the local entity include the sound of walking, running, or moving.
- Sounds from local entity's operated devices are also part of the local entity sounds, such as ammunition clip release or fire

Remote Entity Sounds

- Remote entity sounds can include engine, tracks, missile, rotor blades…
- The representation of remote entity sounds provides important cues that enhance the participant situational awareness

Remote Entity Sounds

- Spatialization of such sounds in either 2 or 3 dimensions further enhance this awareness
- The sound of a remote entity moving in the environment provide crucial cues especially when it originates behind the participant, outside the visual field of view

Environmental Sounds

- Can work with the visual subsystem to provide a more realistic virtual environment
- Sounds from wind, rain, birds, crickets, crashing surf… can add additional clues about the terrain, time of day

Other Sounds

- Other sounds may be included in a simulation:
  - Radio voices
  - Natural voices

Physically-Based Simulation

- Depending on the objectives of the simulation, we may need to generate audio to behave as in real world
- This is the case of high fidelity systems that require the representation of sounds in three dimensions (four if you include time)

Attenuation for Distance

- Distance attenuation is the decrease in energy of the audio effect based on the distance from the listener
- There is also a drop-off in the upper frequencies
- All systems that generate sounds for remote entities and events perform some level of distance attenuation

Spatialization

- The spatialization of an audio effect can be classified as:
  - Diotic, monaural with no spatialization
  - Directional, two-dimensional stereo panning
  - Spatialized, three-dimensional placement of the sound source
- The additional dimension of time can be applied to all the above, simulating the speed of sound propagation delay

Other effects

- Doppler shift: The relative velocities between a sound source and a listener cause the frequency of the sound waves to compress or expand
- Reflection/Echo: The material properties of a surface, as well as the geometric properties of a structure have direct effects on the perception of sound.
  - These effects include echoes, reverberations and absorption

Other effects

- Environment Effects: Wind, temperature, and humidity may affect how sound is propagated in the environment.

  Hills and valleys of the simulated terrain may mask sounds or cause loss of radio communication
- Depending on the needs of the simulation, it may be valuable to simulate these effects

Haptic/Tactile Output

- Haptic displays provide force feedback (joystick …)
- Tactile displays simulate the sense of touch (glove …)
- Can be divide into three types:
  - Movement regulators
  - Object Interactors
  - Event Stimulators

Movement regulators

- This type of devices is used to restrict or enhance movement in some way based on conditions in the virtual environment
  - A device with a variable incline can be used to simulate the changes in terrain slope, which in turn affect mobility

Object Interactors

- This type of displays presents the feel of objects to the touch and may provide some degree of force feedback associated with the resistance of objects such as buttons
- Object interactors can be actual physical objects appropriately positioned in the real world to correspond to a virtual environment counterpart

Event Stimulators

- This type of device generates a discrete event
- An event stimulator might simulate the recoil from firing a weapon or an impact associated with being shot

Delivery

- Haptic and tactile feedback can be delivered using direct or indirect techniques
- Direct haptic and tactile techniques utilize pneumatic, hydraulic, electro-mechanical, or other direct mechanisms to actuate a force or sensation

Delivery

- Pneumatic devices uses compressed air to apply a force to an object or a surface in direct contact with the user
- Hydraulic devices uses fluidic pressure to generate a force that is then delivered directly to the user
- Electro-mechanical displays utilize motors and/or gears to apply pushing, pulling, and resistance forces to the users

Input Subsystem

- Locomotion subsystem translate the motion of the user from physical environment to the virtual environment
- The two essential components of locomotion that must be expressed are direction and velocity

Locomotion Subsystem

- Keyboard/Mouse: the most basic devices that can be used for controlling locomotion in a virtual environment
- The user interface with these devices are not very intuitive

Locomotion Subsystem

- GUI and Touch Screens: A more intuitive approach is to use touch screen input to a graphical user interface
- Intuitive but still unnatural and abstract

Locomotion Subsystem

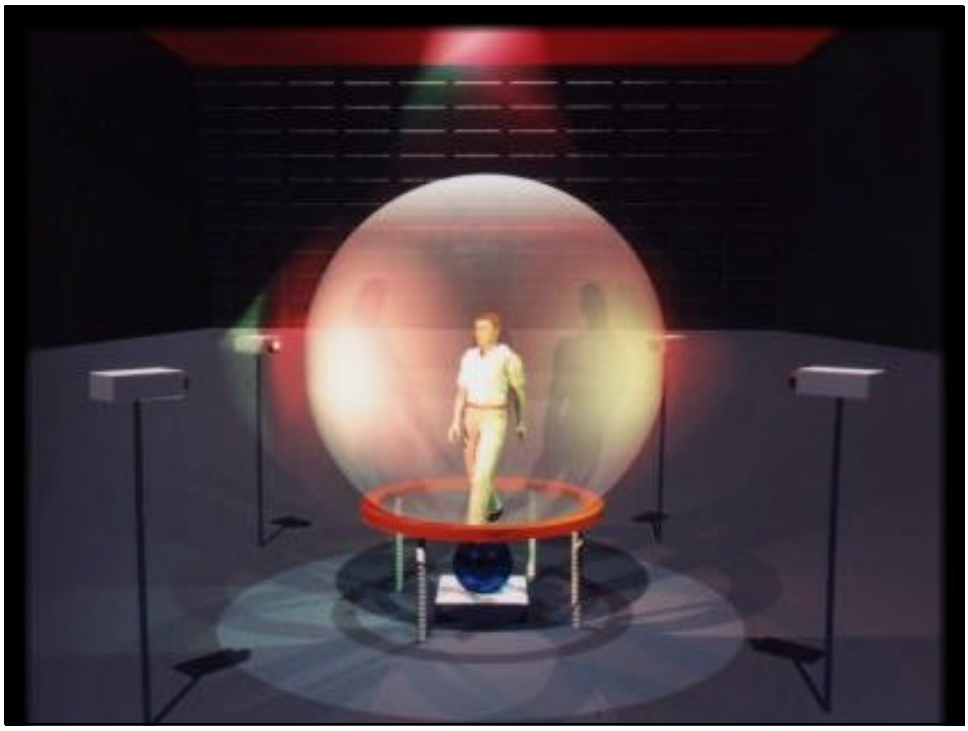
- Joystick is designed specifically for controlling locomotion
- With the addition of throttle control, the user can also control velocity in the environment
- Joystick is most intuitive when used to control the motion of a vehicle

Locomotion Subsystem

- Data Glove is a glove-like device that tracks the position of the hand and fingers.
- It have been used as a locomotion input device by allowing the user to move in a given direction by pointing

Locomotion Subsystem

- Motion Platform have multiple configuration:
  - Uniport
  - Treadport
  - Omni-directional treadmill
  - The cybersphere



Motion Capture/Body Tracking

- The simulation system must detect the user's actions in order to react with appropriate feedback
- The above is called tracking the user's motion.

Tracking

- The tracking subsystem should unencumbering so as not to influence the user's actions
- It should provide reliable, accurate, real-time measurements of the user's position
- Multiple categories: mechanical, electromagnetic, acoustical, optical, and inertial

Mechanical

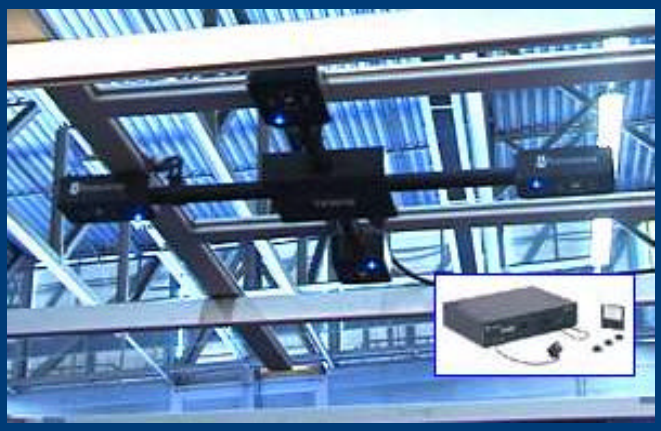
- Uses the relative positioning of various physical components to each other or to a fixed point to determine the position of body parts or objects
- High degree of accuracy, low latency, and high update rate
- Encumbering

Electromagnetic

- The most widely used.
- It employs an emitter to generate an electromagnetic field.
- Sensors are attached to the tracked objects
- Both Position and orientation can be derived
- Inexpensive, good accuracy, can track numerous object at a time
- Sensible to distortion from metallic objects

Acoustic

- Uses ultrasonic frequency sound waves to measure the distances between emitters and receivers
- Some offer high data rate
- Require a clear line of sight between emitters and receivers.
- Is not affected by interference from electromagnetic field or ferromagnetic objects



Optical and Image Based

- One common feature is the use of light to determine position
- Usually uses camera to track either active (light emitting) or passive (reflective) markers
- Only three degrees of freedom per marker (position or orientation)
- Requires a clear line of sight
- No interference problems

Inertial

- Uses small accelerometers on the tracked subject to determine changes in position and orientation
- Can be unencumbering
- Only measure position and orientation changes rather than absolute values
- Have tendency to accumulate error over time

Gesture Recognition

- Motion capture and body tracking can be used as a means of communicating commands
- Gesture recognition can be used to interact with other entities in the virtual environment

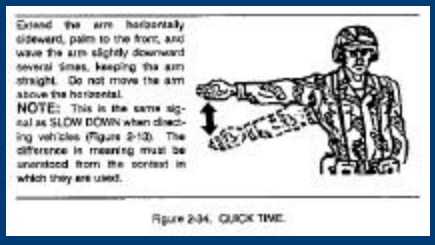


Figure 2-34. QUICK TIME.

Voice

- Voice can also be used as an input, for example, to command other objects or participants in the simulation to do something.
- To use voice in the simulation, the system must be able to capture it, transmit it and interpret it