Virtual Environments

This module provides an overview of what virtual environments can be used for, how they are built, and what technologies are commonly used to implement them

Contents

- Virtual environments
- Software technologies
- Hardware technologies
- 3D applications

Virtual Reality

"Virtual Reality: A computer system used to create an artificial world in which the user has the impression of being in that world and the ability to navigate through the world and manipulate objects in the world."

C. Manetta and R. Blade in "Glossary of Virtual Reality Terminology" in the International Journal of Virtual Reality,

Vol.1 Nr.2 1995.

Virtual Reality

- A virtual reality system…
  - literally puts the user into the simulation loop
  - provides user's sensory inputs with data generated by a computer rather than from the physical world
  - aims to create a *sense of presence*
    - In this context, *presence* is normally defined as a psychological state
    - VR systems aim to achieve a state of psychological immersion, even with limited physical immersion

Virtual Reality

- Equivalent terms used include:
  - Virtual Environments, Artificial Reality, Simulated Reality, Virtual Worlds, Synthetic Environments, Interactive Visual Simulation, Cyberspace, Serious Games, …
- Represents the convergence of many disciplines:
  - Computer graphics, cognitive psychology, cybernetics, database design, real-time and distributed systems, electronics, robotics, multimedia, acoustics, physics, telepresence, …

Classification by display type

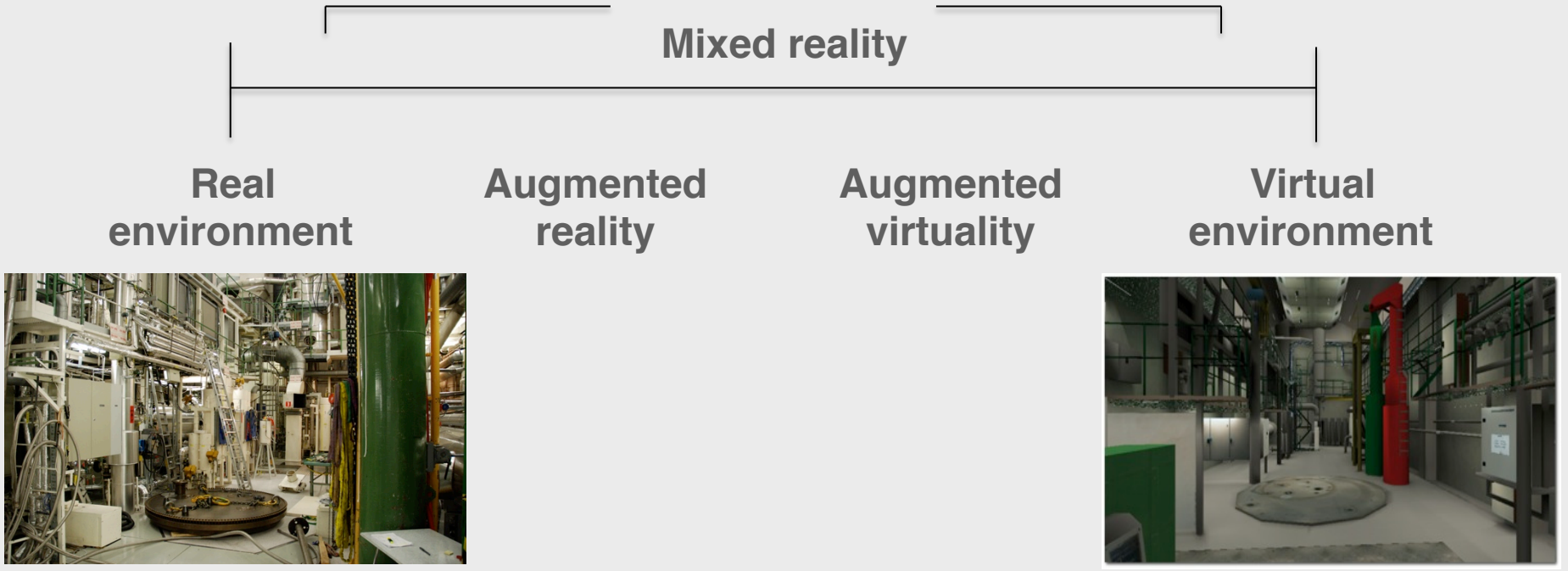
- Research suggests that the higher the level of physical perceptual immersion, the quicker a user will achieve presence
- Visual perception takes precedence over other senses, hence significance in rapidly achieving presence
  - Desktop
    - 3D environment on a computer monitor (may be stereoscopic)
  - Projected
    - 3D environment projected onto a large screen (may be stereoscopic)
  - Semi-Immersive
    - Stereoscopic 3D environment that surrounds the user without totally excluding objects in the physical world from view
  - Immersive
    - Stereoscopic 3D environment seen through a head-mounted display
  - Augmented
    - 3D environment mixed with physical environment (e.g. see-through head-up display)

Mixed Realities

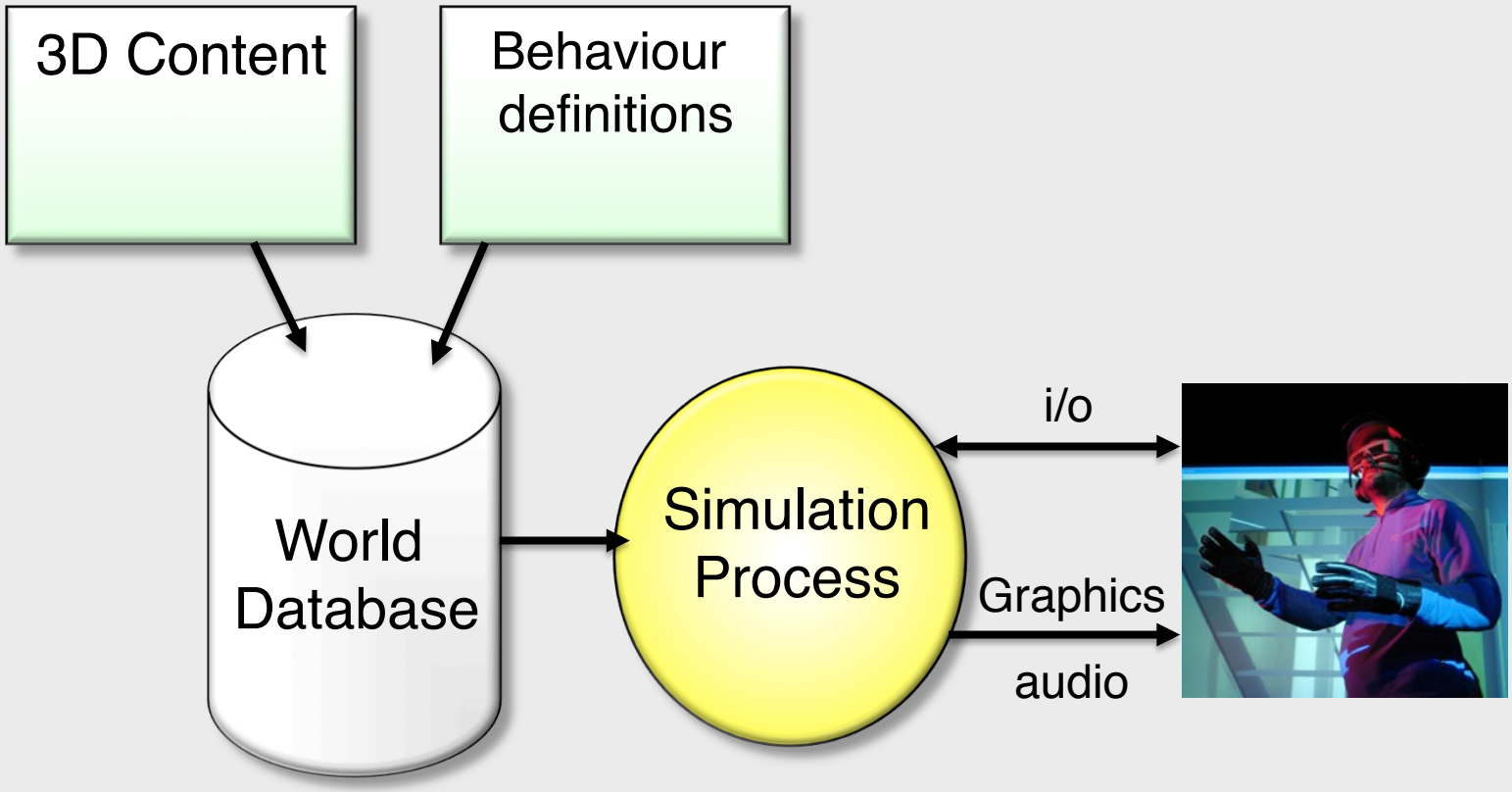
- VR provides a safe, completely artificial environment
- Virtual and real environments can be mixed
  - Enhancing the real with the virtual or vice versa
- Augmented reality has the advantage of not needing to model a complete virtual environment
  - But has additional challenges…

Mixed Reality

Milgram's Reality-Virtuality Continuum



Basic VR/AR system overview



3D software technology

- Content production stage:
  - 3D modelling tools
  - 3D scanning systems
  - Geometry optimisation tools
- Behaviour specification stage
  - Tools/languages and APIs to define semantics, interaction, and presentation
- Run-time stage
  - Real-time visual/audio rendering engine
  - User I/O handling process
  - Simulation process that reads content and interprets behaviour

3D software technology

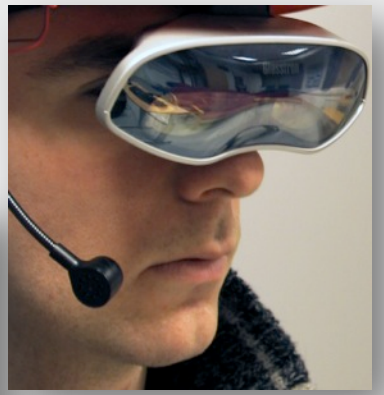
- VR and Game Engines
  - e.g. Blender, CryEngine, Delta3D, Eon Reality, InstantReality, Irrlicht, OGRE, Quake Engine, Torque 3D, Unity, Unreal Engine, Virtools, ++
- Graphics Programming APIs
  - e.g. OpenGL, WebGL, OpenInventor, Coin, OpenSceneGraph, DirectX, JOGL, Lwjgl, Java 3D, jMonkeyEngine, …
  - Typically used together with Bullet and ODE (physics) and OpenAL (audio), and APIs such as for networking, 3D input, AI, Geo-data

3D Software Technology

- Open file formats that can be used to specify both geometry and run-time behaviour: ISO VRML97, ISO X3D, MPEG-4
  - Run-time players: e.g. BS Contact, Cortona, InstantReality, OpenVRML, FreeWrl, …
- Common geometry interchange formats:
  - 3DS, OBJ, ISO VRML97, ISO X3D Interchange profile, Collada/DAE, for interactive 3D software
  - BIM (buildings) and PLM (products) data for 3D CAD, with IGES, STEP, DXF/DWG for geometry data

Visual hardware technology

- Desktop displays
- Head-mounted displays
- LCD shutter glasses
- Virtual retinal displays
- Projection systems
- Auto-stereoscopic displays



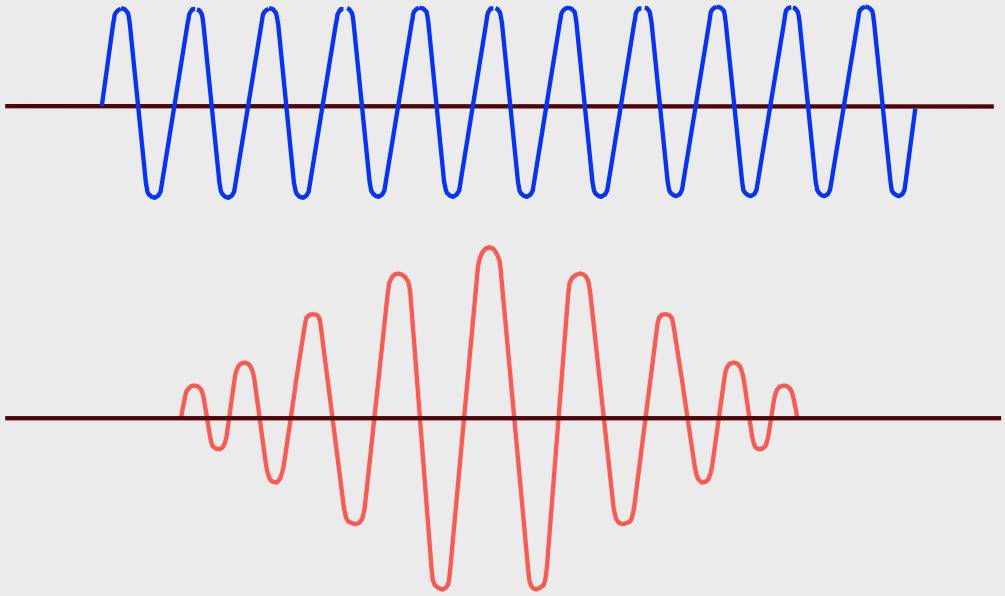
Haptic feedback technology

- Force feedback provides physical constraints
  - Motion platforms
  - Hand controllers
  - Joysticks
  - Exoskeletons

- Tactile feedback provides a sense of touch through, for example, vibrating nodules inside a glove or suit

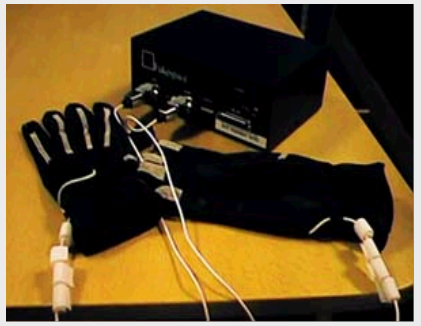
Aural hardware technology

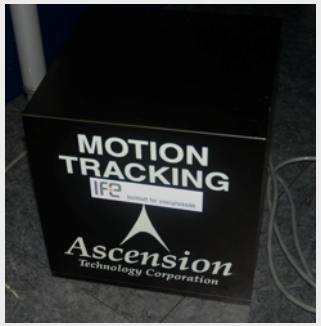
- Spatial audio APIs
- Surround-sound systems
- Microphones
- Headphones

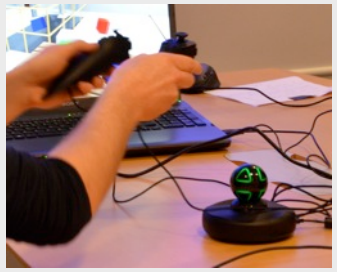


User input hardware technology

- 3D motion/gesture tracking
- Gloves
- Body suits
- Wands
- 3D mice
- Speech recognition
- …





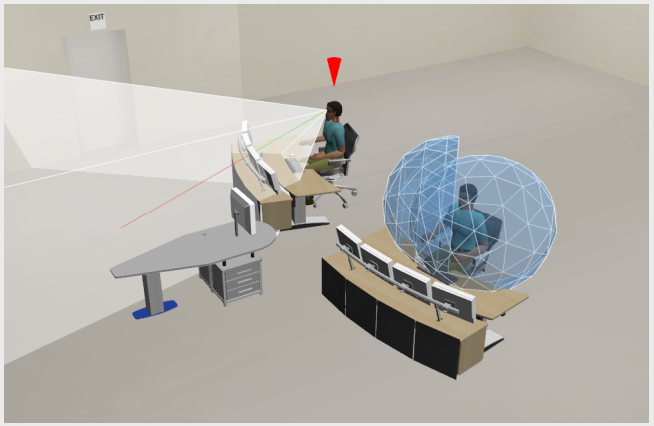


Applications

- Design and prototyping
  - Architecture
    - Can explore a building before it has been built
    - Can demonstrate how a new building development fits into the existing landscape
    - Can interactively perform interior design
    - Recreate the past

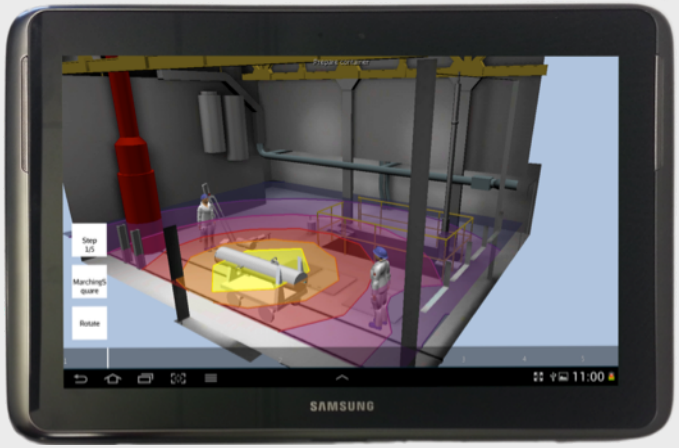
Applications

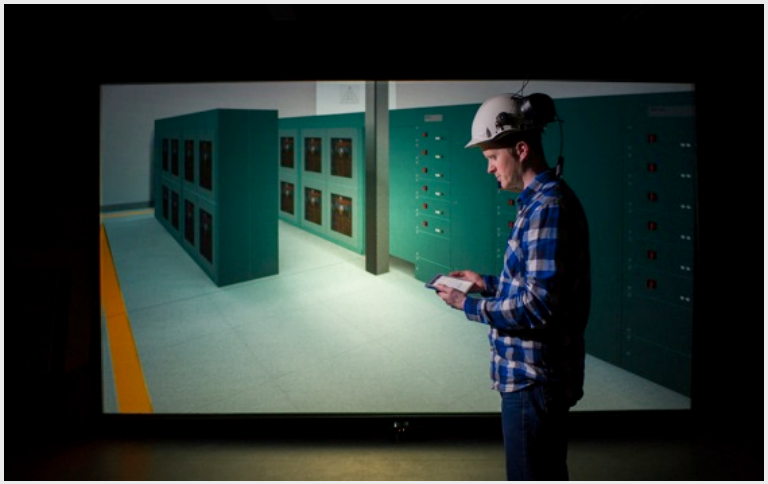
- Design and prototyping (cont.)
  - Product and engineering design
    - Visualise and fly though a design
    - Perform ergonomic studies
    - Analyse collision and clearance
    - Quickly experiment with new design ideas
    - Plan manufacturing and maintenance
    - Simulate interaction with a virtual prototype



Applications

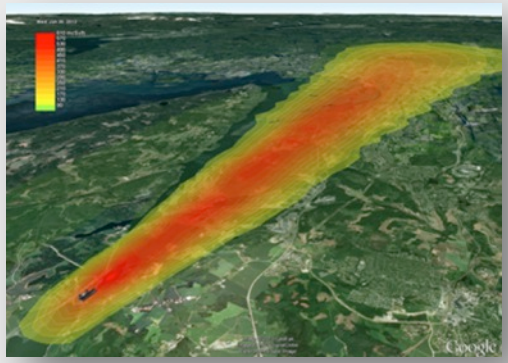
- Training and simulation
  - Vehicle simulators
  - Emergency management
  - Nuclear or chemical plant maintenance
  - Locating and fixing equipment
  - Bomb defusal
  - Surgery
  - Virtual manuals

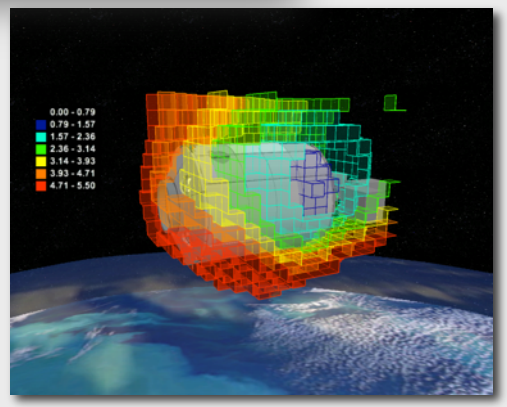




Applications

- Data visualisation
  - View complex data sets to gain greater insight and understanding
    - Complex molecular structures
    - Geological structures
    - Financial information
    - Radiation
    - Weather
  - Visualise satellite data, including terrain data, photos, etc.





Applications

- Conferencing and education
  - Virtual meetings and classrooms
  - Enables virtual teams of experts at geographically remote locations to work efficiently together
  - Team training
    - Less network load than video conferencing
    - Reduce travel costs
- Social networking
- Gaming

Collaborative Virtual Environments

- A *collaborative virtual environment* is a networked virtual environment within which users can interact with each other and the virtual environment regardless of their physical geographical location
  - Shared experience
  - Shared sense of presence
  - Shared understanding of time and space

Summary

- 3D technologies can enable the user to hear, see and *experience* virtual environments
- *Sense of presence* is a powerful differentiator
- Do not necessarily require immersive display hardware to achieve an *immersive* experience
- 3D user interface design is a challenge
  - There are many different technologies available, with different pros and cons…