Communication in Virtual Environments

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Outline

- Goals of the workshop
- Virtual Environments and related topics
- Networked Collaborative Virtual Environments
- Virtual Environments on the Web
- Virtual Humans

Goals of the workshop

- Give a basic understanding of Virtual Environments (VE) and related topics
- Present technologies for using VE in communications
- Discuss applications of presented technologies

Virtual Environments and related topics

- Classification of terms
- Virtual Environment basics
  - Virtual scene
  - Rendering

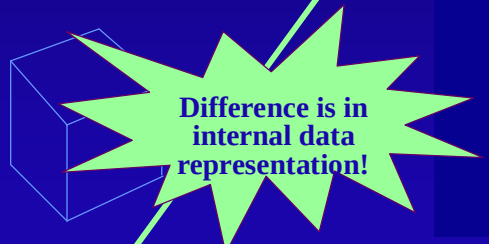
Classification of terms

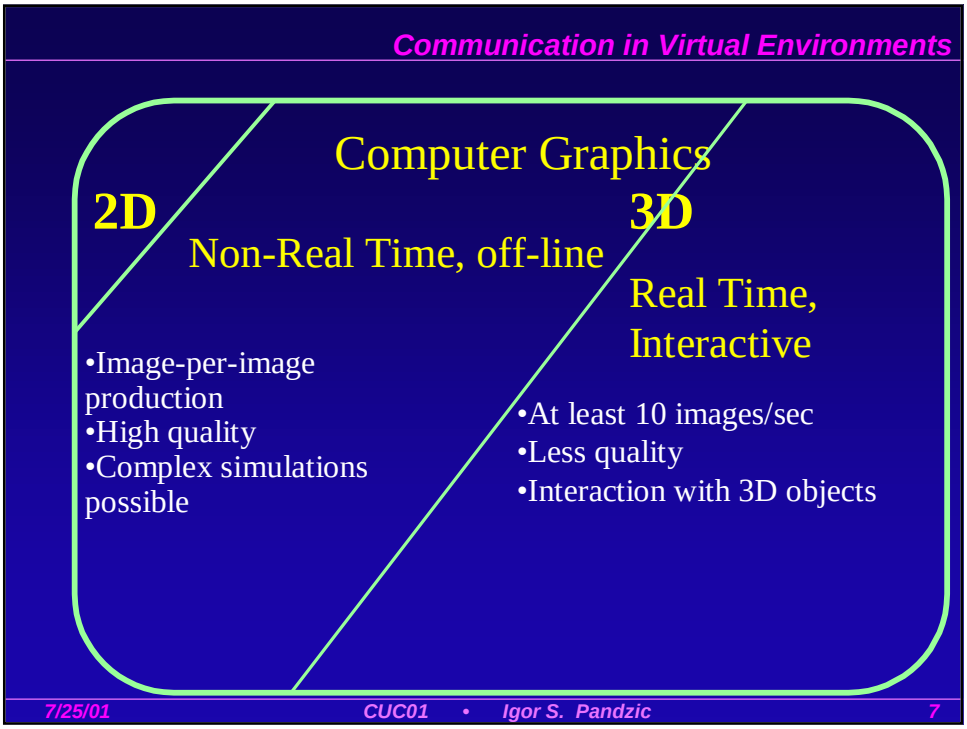
- 2D
- 3D
- Computer Animation
- Real-time graphics
- Virtual Worlds
- Virtual Humans
- Special effects
- CAD/CAM
- Virtual Environments

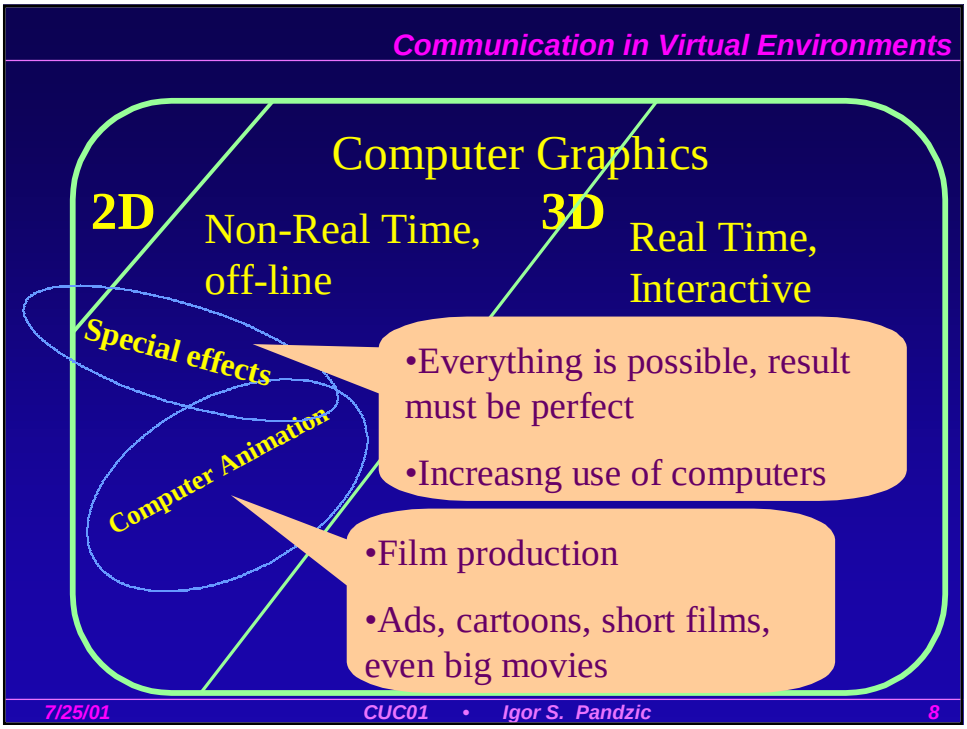
Computer Graphics

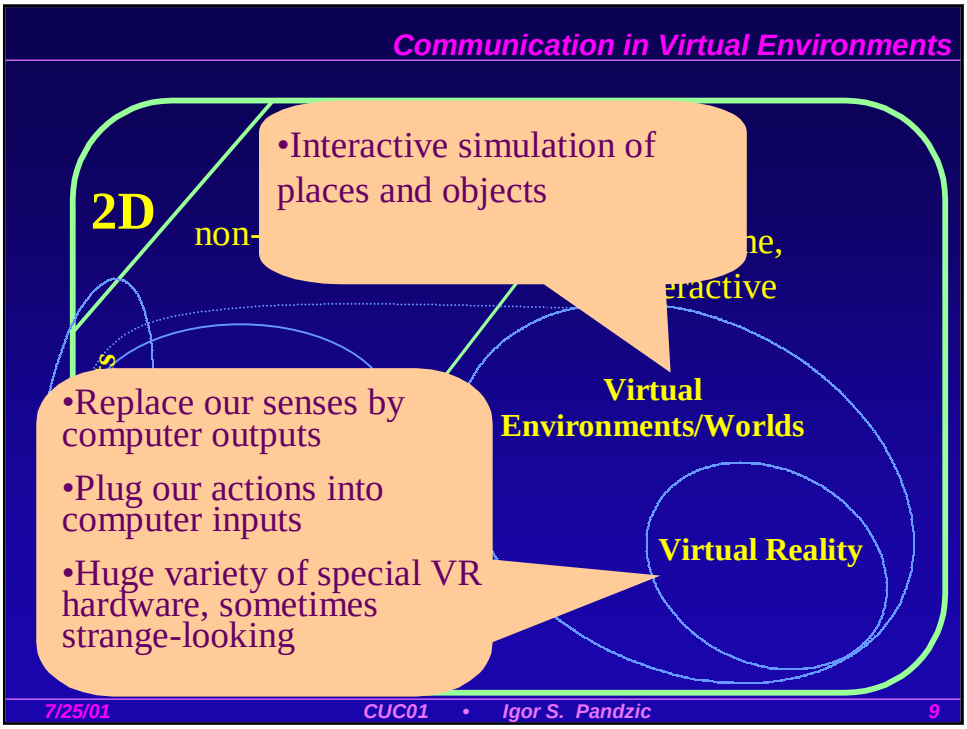
2D graphics
- •GUI
- •PowerPoint
- •PhotoShop

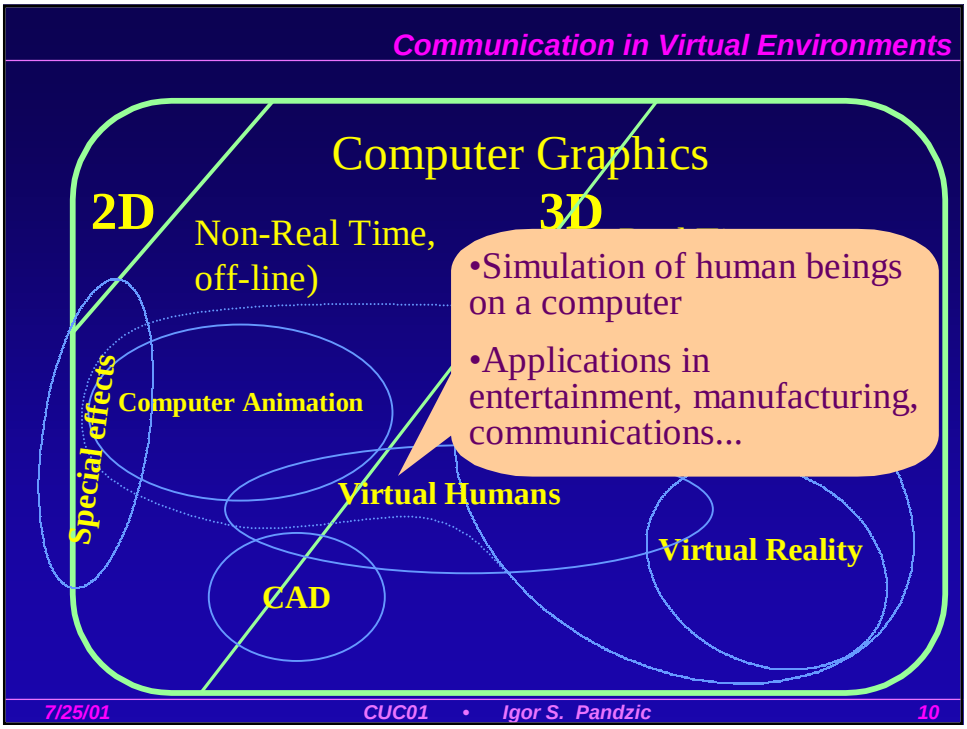
3D graphics
- •Jurassic Parc, Toy Story etc.
- •AutoCAD

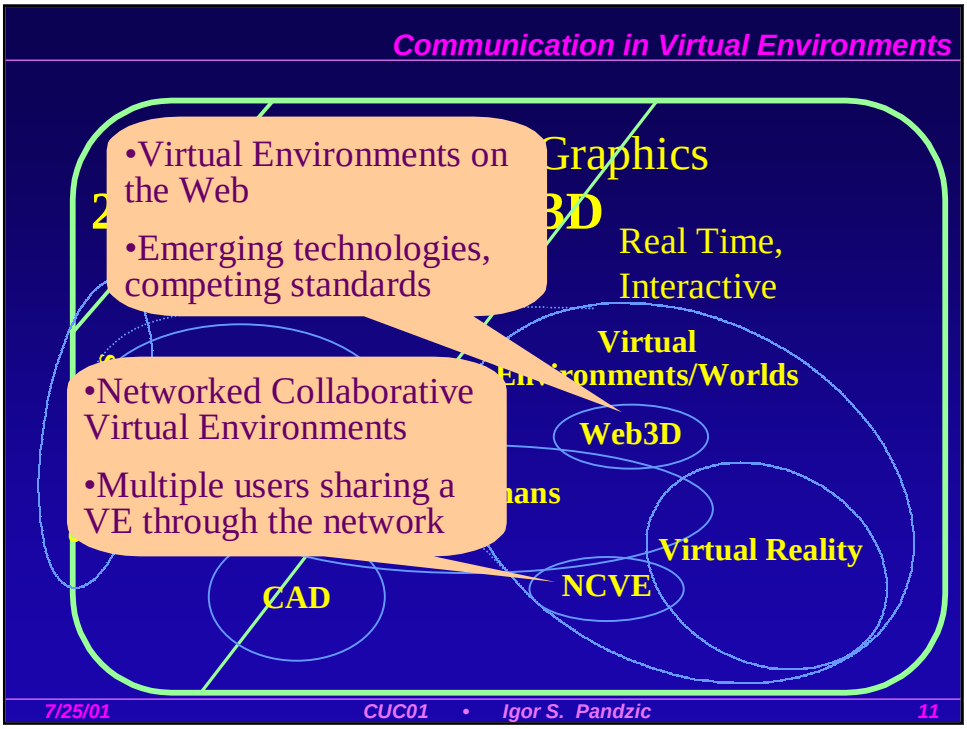



Computer Graphics
2D
Non-Real Time, off-line
3D
Real Time, Interactive
•Image-per-image production
•High quality
•Complex simulations possible
•At least 10 images/sec
•Less quality
•Interaction with 3D objects


Computer Graphics
2D
Non-Real Time, off-line
3D
Real Time, Interactive
Special effects
Computer Animation
•Everything is possible, result must be perfect
•Increasng use of computers
•Film production
•Ads, cartoons, short films, even big movies


2D
non-
•Interactive simulation of places and objects
Virtual Environments/Worlds
•Replace our senses by computer outputs
•Plug our actions into computer inputs
•Huge variety of special VR hardware, sometimes strange-looking
Virtual Reality


Computer Graphics
2D
Non-Real Time, off-line)
3D
•Simulation of human beings on a computer
•Applications in entertainment, manufacturing, communications...
Special effects
Computer Animation
Virtual Humans
Virtual Reality
CAD


Communication in Virtual Environments
•Virtual Environments on the Web
•Emerging technologies, competing standards
Graphics
3D
Real Time, Interactive
Virtual
Web3D
•Networked Collaborative Virtual Environments
•Multiple users sharing a VE through the network
Virtual Reality
NCVE
CAD
7/25/01
CUC01 • Igor S. Pandzic
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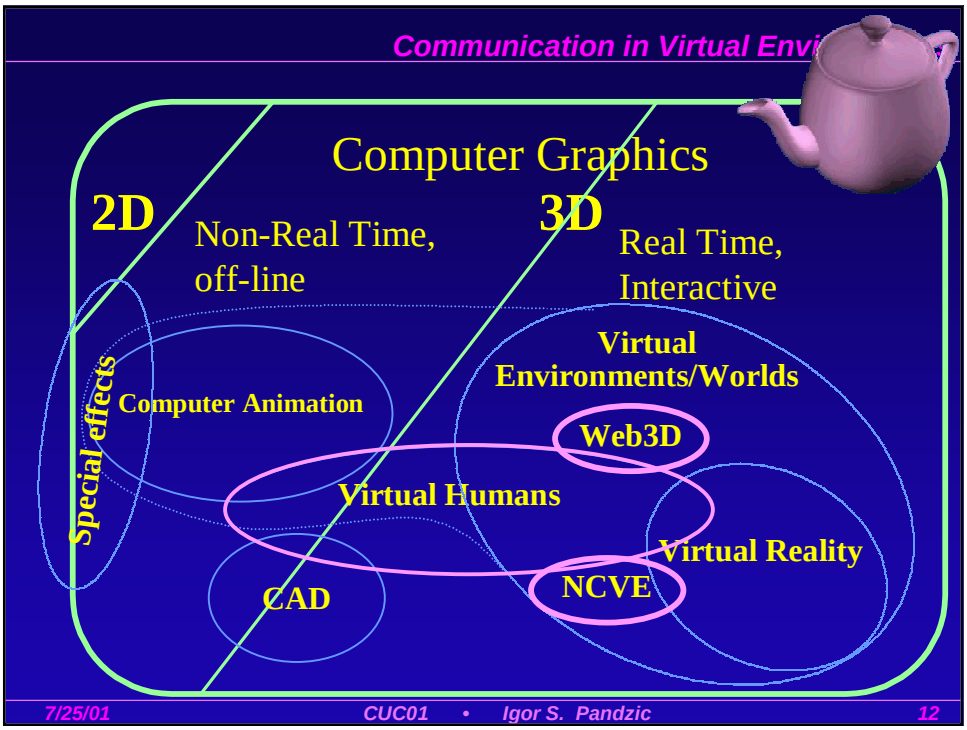
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Web3D
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Virtual Reality
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Digression: The Utah Teapot

- Developped in 1975 at University of Utah (Newell)
- Traditionally used as test object for Computer Graphics algorithms
- It became a symbol of CG

Virtual Environment basics

- Virtual Scene
  - Components of a scene
- Rendering
  - Getting finished images of a virtual scene

Photography scene

Objects
Materials

Light

Photo

Camera

Virtual scene

Virtual Objects
Virtual Materials

Virtual Light

Real Photo

Virtual Camera

Definition of virtual

- Everything that is virtual exists only in computer memory
- This memory is digital, posing two problems:
  - How to represent natural phenomena (objects, lights, etc.) digitally?
  - How to get a nice image out of it in the end?

Rendering

Virtual Objects
Virtual Materials

Virtual Light

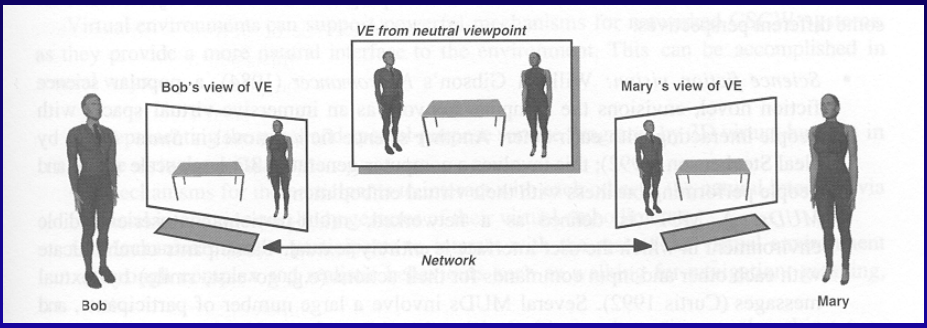
Real Photo

Virtual Camera

Networked Collaborative Virtual Environments

- Basic concept
- Technical challenges
- Example NCVE systems

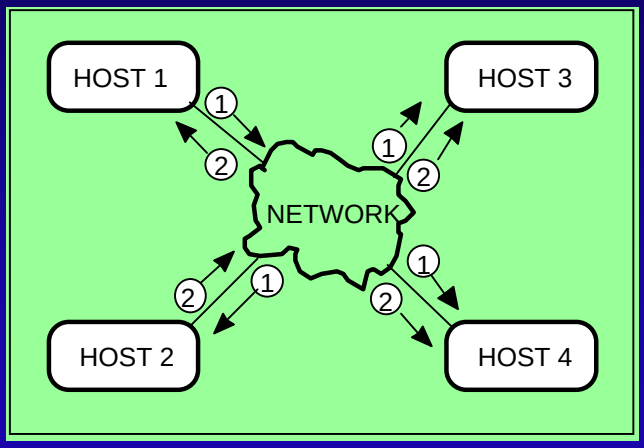
NCVE - basic concept



- Geographically distant users interact in a shared Virtual Environment

How does it work?

VERY simplified explanation:



NCVE technical challenges

- Scaleability
- Network topologies
- Space structuring
- Real time simulation
- User representation
- Human communication

Scaleability

- Problem:
  - How to support increasing numbers of users?
- Solutions:
  - Clever network topology
  - Space structuring
  - Area Of Interest Management (AOIM)
  - Level Of Detail (LOD) management

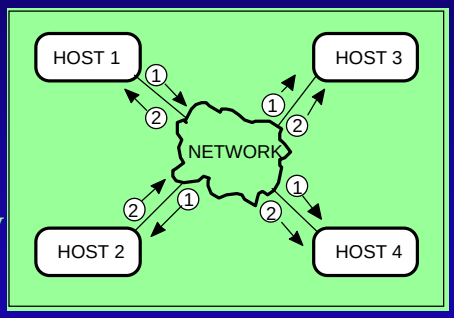
Network topologies

Problem:

- Efficient message transfer
- AOIM support
- Session management
- World persistence

Solutions:

- Peer-to-peer topology
- Multicast topology
- Client/server topology
- Multiple servers topology



Space structuring

Problem:

- Divide the VE into manageable units with respect to:
  - number of users
  - world data base size
  - coordinates precision

Solutions:

- Separate servers
- Uniform geometrical structure
- Free geometrical structure

Real time 3D simulation

- Problem:
  - Display the VE at interactive frame rates
- Solution:
  - Use a real time toolkit including:
    - LOD management
    - Hierarchical scene graph management
    - Parallel scene graph traversal
    - Good integration with hardware

User representation

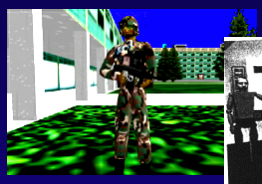
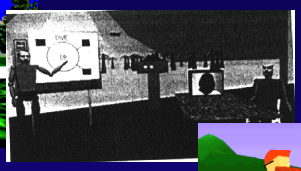
- Problem:
  - Let the users perceive each other
- Solutions:
  - Simple cube-like appearances
  - Non-articulated characters
  - Articulated rigid-segment body
  - Deformable body and face

Human communication

- Problem:
  - Support life-like communication in NCVE
- Solutions:
  - Text
  - Audio
  - Gestures
  - Facial expressions

NCVE systems

- NPSNET
- DIVE
- SPLINE
- VLNET
- Blaxxun
- Doom
- Adobe Atmosphere


Potential applications

- Virtual teleconferencing
- Collaborative work involving 3D design
- Multi-user game environments
- eCommerce
- Medical applications
- Distance learning/training

Virtual Environments on the Web

- Why VE on the Web?
- Possible solutions for VE on the Web:
  - VRML / X3D
  - MPEG-4
  - Java3D
  - Java applet solutions
  - Plug-in solutions
  - Substitute solutions (“false 3D”)

Why VE on the Web

- Enable 3D content on the Web
- Better visualization in many fields
- Enable new applications

VRML

- Virtual Reality Modeling Language
- ISO Standard since 1997. (VRML97)
- Syntax for describing virtual scenes
- Scene Graph concept - objects placed in a tree
- Animation with sensors, interpolators
- Programming with scripts or external applications

VRML

- Most important standard format for 3D data
- Problems:
  - ASCII, heavy, needs encoding (solutions exist, but not standard)
  - not (yet) universally available in browsers - plug-in required
- New version in development

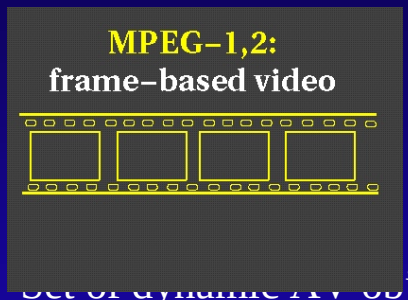
VRML 200X

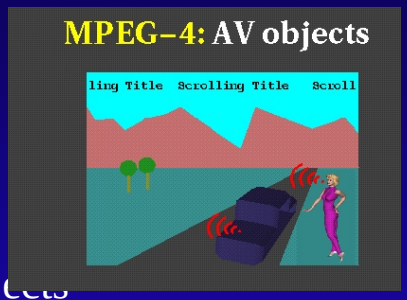
- International Standard ISO/IEC 14772:200X
- Next generation of VRML
- Improve functionality (new nodes, external interfaces, object model, profiles, web integration)
- Improve encoding (XML and binary versions)

MPEG-4

- International Standard ISO/IEC 14496
- IS status 1999 for version 1), 2000 version 2
- Huge industrial participation
  - several hundreds of experts involved
  - estimated $500M spent so far
- Includes very extensive tools for audio, video and 3D object coding

MPEG-4: New paradigm for AV coding





- Set of dynamic AV objects
- Composition on decoder
- Interaction
- Synthetic objects

3D in MPEG-4

- Based on VRML
- Efficient encoding: **BI**nary **F**ormat for **S**cenes (BIFS)
- Data streaming, animation streaming
- Special nodes
  - Face and Body Animation
  - Animated mesh

Java3D

- Java API for 3D graphics programming
- high-level API
- Problems
  - performance?
  - Not a core part of Java, difficult to install in a browser

Java applet solutions

- Applets capable of rendering interactive 3D graphics (usually VRML)
- Avoid need for plug-in, therefore the most practical solution at the moment
- Problems:
  - size of the applet
- Some examples:
  - www.shout3D.com
  - www.blaxxun.com

Plug-in solutions

- 3D renderer in a browser plug-in
- Problems:
  - No widespread standard (yet!)
  - Need to download and install
- Some examples:
  - www.cult3D.com
  - www.pulse3D.com
  - www.macromedia.com/software/shockwaveplayer

Substitute solutions ("false 3D")

- Use other techniques (usually image based) to achieve a semblance of 3D
- Panoramic images
- Animations
- Examples
  - Quicktime VR: www.apple.com/quicktime/qtvr/
  - www.mgisoft.com (like Quicktime, but better)
  - Talking Virtual Characters: www.winteractive.fr

Future of VE on the Web

- Technical challenges to bring Virtual Environments to the Web are being solved
- Lots of interest in industry
- What will be the killer application?

Virtual Humans

- Basic concepts
  - Representation
  - Animation
  - Behaviour
- Virtual Humans in NCVEs
- Standards for Virtual Humans
- Virtual Humans on the Web
- Applications for Virtual Humans

Virtual Humans

- Simulation of human beings on computers
  - Representation
    - Graphical
    - Functional
  - Animation
  - Behavior

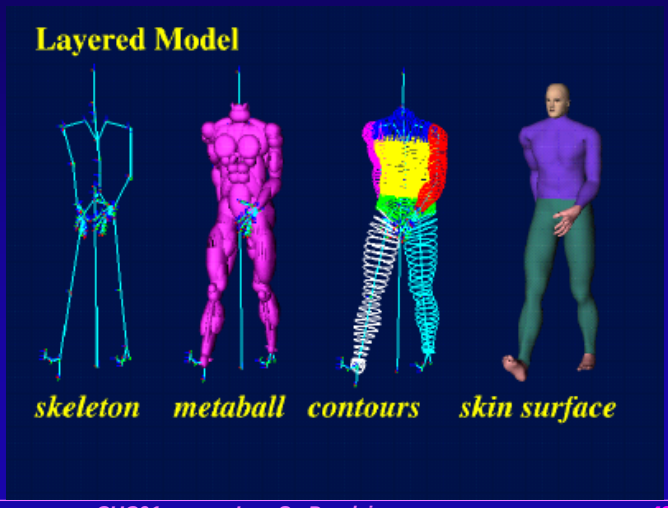
Graphical representation

- To define the shape and color properties of the virtual human
  - Skin
  - Clothes
  - Hair
  - Material properties

Functional representation

- The data structures necessary for the animation of the virtual human
- Skeleton
  - Necessary for body animation
  - Usually simplified
- Facial structure
  - Necessary for facial animation
  - Usually contains data on facial regions or characteristic points (lips, eyes, eyebrows etc.)

- Functional and graphical representation must be linked - this usually means some more data

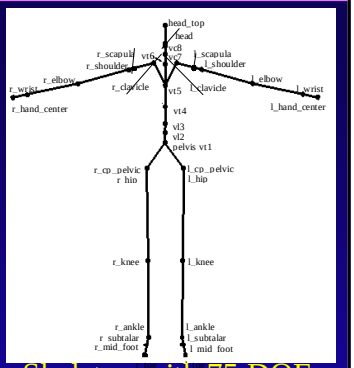


Animation

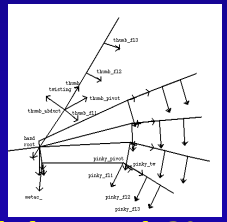
- Body animation
- Skin deformation
- Facial animation
- Clothes animation
- Hair animation

Body animation

- Body is animated by animating the skeleton
- A good approximation of anatomycal skeleton: 75 Degrees of Freedom + 2x30 DOF for hands, mostly rotational
- Real skeleton has many more, including translation
- Rougher approximation often used



Skeleton with 75 DOF



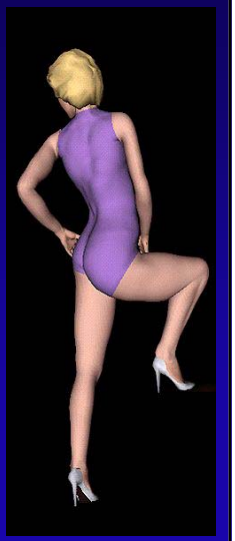
Hand skeleton with 30 DOF

Body Animation

- Complex because of many degrees of freedom
- Use of inverse kinematics
- Optical or magnetic body tracking often used to obtain real movement data

Skin deformation

- Based on skeleton movement, skin deforms
- Relatively complex, often ignored (body composed of rigid segments)



Facial animation

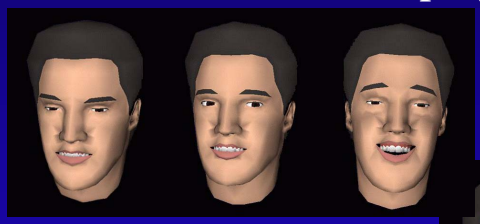
- Face: extremely important communication channel
- Even slightest facial expressions meaningful
- Extraordinary complexity of bone and muscle structure

Facial Animation

- More complex simulation systems try to approximate muscle dynamics, others concentrate on geometrical effect on the skin
- FA system is usually controlled by a set of parametres activating facial actions

Facial Animation

- Some FA systems work only with very high-level parameters: text to pronounce and emotions to display



Clothes animation

- Most often, clothes are represented as colour on the body geometry - no separate layers for skin and clothes
- More sophisticated models simulate clothes physically

Hair animation

- Most often ignored (rigid hair model)
- Models for hair animation: encouraging results, but very computing-intensive
- Successful fur simulation seen in movies

Behaviour

- Simple behaviors can be achieved
  - Walking, walking on trajectory
  - Obstacle avoidance
  - Grasping objects
- High level autonomous behaviour (research)
  - Decision-making
  - Interaction with users

Reasons for Virtual Humans in NGV

- Requirements on user representation:
  - Perception
  - Localization
  - Identification
  - Visualization of interest focus
  - Visualization of actions
  - Communication
- Can a simple representation (e.g. a cube) meet the requirements?

Standards for Virtual Humans

- MPEG-4
  - Face and Body Animation (FBA)
- VRML
  - H-ANIM

Virtual Humans on the Web

- Very new area
- Potential usage as virtual hosts, presenters, salespersons, newscasters etc.
- Technology:
  - images
  - video streaming
  - Java applets
  - 3D plug-ins

Virtual Humans - Applications

- Film and TV
- Ergonomy studies (vehicles, furniture etc.)
- Work process efficiency studies
- Clothing industry
- Games
- Telecommunication
- Medical simulations
- Web, eCommerce

Further reading

- ***3D Computer Graphics***, Alan Watt, *Addison-Wesley*
- ***Introduction to Computer Graphics***, Foley, Van Dam, Hughes, Phillips, *Addison-Wesley*
- ***Avatars in Networked Virtual Environments***, Capin, Pandzic, Magnenat-Thalmann, Thalmann, *John Wiley & Sons*
- ***Networked Virtual Environments: Design and Implementation***, Singhal, Zyda, *Addison-Wesley*
- ***Computer Facial Animation***, Parke, Waters, *A K Peters Ltd.*
- ***Vrml 2.0 Sourcebook***, Ames, Nadeau, Moreland, John Wiley & Sons
- Web3D consortium: ***http://www.web3d.org***
- MPEG-4: ***http://www.cselt.it/mpeg/***
- Java3D: ***http://java.sun.com/products/java-media/3D***
- ***http://web3d.about.com/compute/web3d/***