VR & AR Frameworks for Virtual Character simulation

State-of-the-art

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Presentation Outline

- **In Short**
- **State of the Art**
- **Future Trends**
- **Short Case Study (VHD++)**
In short: the wave

- **real-time 3D graphics**
  - **revolution** performance, price
  - **game industry surpasses movies** the date: 2001
  - **dynamic synthetic characters** omnipresence
In short: the must

VR/AR system development methodology

✓ must face it

- each time deliver ... new ... more ... in shorter time... go!
- large scale reuse: design + code
- extensions + integration
- rapid prototyping
- big teams
In short: the consolidation rule

- **Consolidation -> natural process**
  - **Car industry**
    - 70s....hundreds of manufacturers
    - Nowadays few important players
  - **Aviation industry**
    - US: Boeing, EU: Airbus
  - **3D character modeling tools**
    - US: Kinetix 3DSMax, US: Alias Wavefront Maya
  - **Game consoles**
    - Sony Playstation, Microsoft XBOX
  - **VR/AR systems**
    - car industry in 70s ... ?
In short: the change

VR/AR systems development methodology

- application
- toolkits
- thin application
- framework
- plug-able extensions

now:
- hundreds of solutions
- no standards

soon:
- 2 - 5 dominating solutions?
- standarized methodology?
In short: US/Japan strong lead

➢ US / Japan
  - ongoing consolidation
    ▪ Quake III
    ▪ Unreal
    ▪ Alchemy
    ▪ MR Platform
  - price tag
    ▪ 10,000 ... 250,000 USD
  - still no standards

➢ EU
  - growing consciousness
  - multiple initiatives
  - urgent need of concertation
State of the Art

- VR/AR systems for
- virtual character simulation
“Recent Advances in AR” [AZUMA2001]

- Complementary to “A Survey of Augmented Reality” [AZUMA1997] with examples of new advances
- Current state of the art in Augmented Reality
- Publishes extensive bibliography of papers in the field (88 papers)
- Not our current aim!
- We focus on AR Frameworks for Virtual Characters (Humans, animals, plants, dynamic scenery etc.)

Architectures in “Recent Advances in AR”[AZUMA01]

- **AR Games**
  - AR hockey, RV-Border Guards, AquaGauntlet, ARQuake, ARpool

- **AR Academic Platforms & Tracking toolkits**
  - BARS, Tinmith, Touring Machine, Augmented Surfaces, Emmie, Archeoguide, ARToolkit, TownWear, NaviCam, Transvision, Studierstube

- **AR Commercial Platforms & Tracking toolkits**
  - ARVIKA, MR Platform, InterSense’s Constellation, 3rdTech’s HiBall, Kanade’s 3D dome, Fox Trax

- **Few of these deal with Virtual Characters!**
Framework platforms?

- **application**
  - highly optimised to do a particular job
  - usually based on a set of toolkits
  - reuse: difficult

- **toolkit**
  - set of predefined, related and reusable classes doing certain job
  - reuse: code

- **framework**
  - partially completed application pieces of which are customized and extended by the user to complete the application
  - large scale reuse: design & code

- **How do they relate with 3D graphics Image generators?**
Evolution of Image Generators*


www.miralab.unige.ch

LIFEPLUS: STAR of AR-VR Virtual Character Frameworks

vrlab.epfl.ch
a Scenegraph Toolkit not a VR framework?

- As Arnaud and Jones report [ARNAUD1999]
  - Week extension model
  - Limited code reuse
  - Difficulties in integration
  - Duplication of Application state

- Scenegraph is a victim of its own success!

For Virtual Character Simulation?

- Enhance AR experiences in:
  - Engineering
  - Virtual-Conferencing
  - Interaction
  - Monitoring
  - Virtual Environments
  - Games
  - Training
  - Education
  - Design/Maintenance
Advantages of frameworks

- **Rapid prototyping**
- **Scientists don’t have to be expert programmers**
- **Integration of various simulation technologies**
- **Curbing complexity**
- **Code reuse & design reuse**
Advantages of frameworks

- cutting development time
- staying within expertise, developing in parallel
- flexibility
- customisations, replacements, extensions
- consistent development framework (e.g. Java)
Quotes

- **Quote from Mike Milliger, Lead programmer at 2015 (GameDeveloper Magazine, June 2002)**
  - “the more prized skill among game developers is now in evaluating, choosing and integrating licensable technologies, not in developing new ones” (Medal of honour: Allied Assault, Freedom force, DARK AGE OF CAMELOT used the Quake Engine)

- **Bill Raduchel, Chief Strategy Officer of Sun Microsystems:**
  - “The challenge over the next 20 years will not be speed or cost of performance; it will be the question of complexity”
Modern AR application for virtual characters?

- **It is a complete VR framework**
  - Kernel = “game engine”
    - Complex 3D Scene Rendering, Virtual character animation/deformation
    - AI system, Motion retargeting/blending, 3D sound, Authoring tools
    - And many many more features....

- **With extra AR capabilities ("AR enabling technologies")**
  - Real time camera tracking
  - AR Displays and interfaces (HWD, Handheld, projection)
  - Registration & Calibration

- **Such New AR applications are integrated in a mobile, wearable kit!**
VR-AR frameworks for Virtual Character Simulation

- MR Platform
- Alchemy
- Quake III
- Unreal
- Renderware
- Archeoguide
- AR-Quake
- AR-Toolkit
- Jack
- VLnet
- VHD++

Commercial

Academic-Research
Hypothetical AR platform for Virtual Characters

- Quake Game Engine + AR-Toolkit + Wearable Computer?
- It has been done: ARQuake [PIEKARSKI]
- Not the ideal solution!

"{PIEKARSKI} ARQUAKE, The outdoor Augmented Reality Gaming system", Piekarski, Thomas, In Communications of the ACM, Vol 45 No 1, January, 2002 - Copyright (C) 2001 ACM
SOTA VR Framework: Alchemy*

- **Scene Graph**
  - high-level shaders, animation support, visibility culling, occlusion culling, collision detection, intersection processing, visibility pre-processing, multi resolution meshes

- **Sound**
  - DirectSound support for DirectX 8

- **Animation**
  - Flexible skin-and-bones character animation support

- **Core, Performance Analysis**
  - System services: process management, timers, alarms, synchronization, memory management, file access

- **Textures, Art Tool Integration**

- **Exporters, Development Environments**

* http://www.intrinsic.com
SOTA VR Framework: QuakeIII*

- One of the most successful 3D game engines
- Shaders,
- Curved surfaces,
- Dynamic lighting - lightmaps,
- Special effects,
- Multiplayer networking
- OpenGL hardware rendering
- Particle System support
- Technology licensed for many game titles

* http://www.quake.com
SOTA VR Framework: Unreal*

- Dynamic scene graph technology
- Editing Tools
- Mesh animation
- Rich, organic surface support
- Artificial Intelligence
- Networking
- Digital Music System
- Technology licensed for many game titles

* http://unreal.epicgames.com/)
SOTA VR Framework: Renderware*

- game development framework incorporating 2D/3D graphics, audio and physics modules
- Modeler's Support
  - 3ds max, Character Studio, Maya and SOFTIMAGE 3D plug-ins
- Animation Support
  - Hierarchical Skeletal animation - 4 weights per vertex
- Environment Features
  - Multipass texturing, Cameras, Lights and Geometric Objects
- Very large worlds (PVS support)
- Multi-Platform (PlayStation® 2, PC, Xbox™, NINTENDO GAMECUBE™)

* http://www.renderware.com
Jack is a human modeling and simulation software solution [BADLER]

Jack enables you to:
- Build a virtual environment
- Create a virtual human
- Define your human’s size and shape
- Position the human in your environment
- Assign your human tasks
- Analyze how your human performs

Initially developed at the “Center for Human Modeling and Simulation”, currently is commercially available by PLM solutions*

* http://www.plmsolutioneds.com/products/efactory/jack/

SOTA AR Frameworks: MR Platform*

- **Outcome of the National MR project in Japan [TAMURA]**
- **Stereoscopic video see-through COASTAR HMD**
- **Each HMD is supplied as a package named “MR Platform”: SDK for developing various AR applications**
  - C++ library classes for implementing an MR application:
    - 6DOF sensor handling, video capturing, marker detection, registration, and others
- **more than a dozen of AR application systems by MR Lab**
- **release is scheduled in the end of 2002**

*http://www.mr-system.co.jp/canon-mr/

[TAMURA] Overview and Final Results of the MR Project, Hideyuki Tamura, Mixed Reality Systems Laboratory Inc.
SOTA AR Frameworks : ARCHEOGUIDE*

- Mobile AR-Unit
- Vision Based Tracking
  - Image based rendering of 3D scenes
- GPS + digital Compass
- Avalon VR toolkit
- Virtual Characters: VRML Avatars
  - VRML Animation, exported as 2D animated PNG images
  - Applied to transparent geometry as animated movie texture map

* http://archeoguide.intranet.gr/
SOTA AR Frameworks : ARQuake*

- Based on the Tinmith Mobile AR unit
- Quake Engine + ARToolkit [PIEKARSKI]
- GPS & Digital compass, 2 button Input device, See-through HMD

- Pros:
  - First hybrid approach of a full game engine in AR

- Cons:
  - Speed, accuracy, latency, marker based, visual quality, FOV, occlusions, optical see through display

http://www.tinmith.net/arquake.htm

"{PIEKARSKI} ARQUAKE, The outdoor Augmented Reality Gaming system", Piekarski,Thomas, in Communications of the ACM, Vol 45 No 1, January, 2002 - Copyright (C) 2001 ACM
**SOTA AR Frameworks : ARToolkit-Magic book**

- **Computer vision techniques for marker based real-time camera tracking**
- Based on OpenGL & GLUT
- Support for video&optical see through HMDs
- *Magic Book application*[BILLINGHURST]*
  - Collaborative MR experience (AR and full immersive VR)
  - Virtual Characters: avatars, VRML content
  - handheld augmented reality display (HHD),

*http://www.hitl.washington.edu/research/shared_space*

**SOTA AR applications: Welbo**

- *Embodied Conversational Agent in MR space*
  - Conversation, Behavior
  - Awareness, Embodiment

- See-through HMD
- Interaction with virtual and physical objects
- can understand the user's demand, to move and replace the virtual objects

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SOTA AR applications: AquaGauntlet

- Extension of technology of ARHockey, RV-Border Guards
  - three players,
  - surrounding a physical game field
  - wearing HMDs
  - defend the border between the real and virtual worlds
  - destroying virtual invaders
Conclusions: VR Frameworks for Virtual characters

- **Game engines** (e.g. Quake III) are top-down frameworks that encompass all technical aspects of game development
  - complete,
  - off-the-shelf solution
  - you can focus on your gameplay (simulation) and content

- **Game components** (e.g. RenderWare) are aimed at developers who
  - are developing their own technology,
  - don't want to reinvent the wheel in some area of technology that's already well-defined.
Conclusions: VR Frameworks for Virtual characters

- **Game engines have the advantage of solving the complete set of technical problems**
  - *But they cannot be easily adjusted to all kinds of simulations*

- **Game components can be easily tailored to fit your purposes**
  - *But often come without source code*
  - *You must integrate them with the rest of your system*

- **Cost-loyalties-source licensing agreements?**
Conclusions: AR platforms for Virtual characters

- Still at the very beginning
- A hybrid approach based on VR frameworks + AR enabling technologies is very promising!
- But has the drawbacks explained before
- Current STAR of AR comparable to early years of VR
  - Many research systems demonstrated
- Why?
  - Technological limitations
  - User interface limitations
  - Social acceptance
Future Challenges

"We expect that within the next 10-20 years what we call today a Game Engine will become one of the most advanced and complex operational engineering entities ever conceived by human beings that will be pervasively melting inside all existing branches of IT."

Why?

3D is an exciting Growth market

- A very large market (over 200 million unit annual market)
- Compelling content
- End User passion

New hybrid VR-AR framework approaches are needed
Future Trends

NVIDIA – Moore’s Law

GPU Performance (32 bit AA Fill Rate)

NVIDIA GPU’s

Intel CPU’s

CPU Performance (Megahertz)

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Future Trends

Convergence of Film and Real-time Rendering

Advanced GPUs -> High Quality AR experiences with virtual Characters

© 2002 NVIDIA Corporation
**VHD++**

*Development Framework*

**Overview of Applications**

- what we currently use it for …
- … growing spectrum of applications
**VHD++ concept**

The VHD++ Development Framework

- **Runtime Engine**
  - **Kernel**
    - **Sharable Data**
      - e.g. vhdSoundService
      - e.g. vhdViewerService
  - **Net Devices**
  - **Multimedia I/O Devices**
  - **Sound Devices**
  - **Other Devices**
- **Direct Kernel communication**
- **Active plug-in service with Heterogeneous Technology**
- **Content Database**

**LIFEPLUS: STAR of AR-VR Virtual Character Frameworks**
VHD++ in numbers

- **framework**
  - more than ~500 classes
  - grouped into ~35 packages including ~10 kernel packages
  - already ~14 existing vhdServices (big plug-in components)

- **development effort**
  - ~40 contributing experts / researchers / developers
  - ~10 direct developers
  - ~3 kernel designers / lead programmers
  - design and development started in March 2000 (2.5 years)

- **now in real-world application tests**
  - used in multiple EU level and national level projects
  - becomes quickly main real-time framework solution for MIRAlab and VRlab research and development in VR/AR domain
growing spectrum of apps

- **vhd JUST**
  - immersive VR health emergency personnel training

- **vhd CAHRISMA**
  - VR reconstruction and preservation of cultural heritage

- **vhd STAR**
  - AR training of hardware maintenance professionals

- **vhd LIFEPLUS**
  - AR edutainment reconstruction of ancient life in Pompei (Italy)

- **VR**
  - games
  - edutainment

- **AR**
  - infotainment

- **VHD++**
  - LIFEPLUS: STAR of AR-VR Virtual Character Frameworks
vhd JUST

- immersive VR health emergency personnel training
**vhd JUST**

> interplaying technologies:

- **network deployment**
  - simulation runtime engine networked with
  - GUI equipped simulation controller

- **immersive 3D graphics**
  - stereoscopic rendering
  - shutter glasses or HMD support

- **immersive 3D sound**
  - home cinema 5.1 surround sound
  - real time environmental effects

- **VR interaction**
  - intuitive VE navigation paradigm
  - using head magnetic tracking

- **interactive scenario**
  - interactive authoring GUIs
  - interactive execution GUIs

- **virtual human animation**
  - skeleton animation
  - walking engine
  - keyframes
  - animation mixing
  - skin deformation
  - face animation mixing
  - face deformation
  - speech

- **others**
  - VRML, HANIM, XML, MPEG-4, …
vhd CAHRISMA

- VR reconstruction and preservation of cultural heritage
Interplaying Technologies:

- High performance 3D graphics
  - Huge model rendering
  - Realistic lighting effects

- Immersive 3D sound
  - Home cinema 5.1 surround sound
  - Real-time environmental effects

- VR interaction
  - Intuitive VE navigation paradigm
  - Using head magnetic tracking

- Speech recognition
  - Giving orders to the system
  - Changing point of views

- Virtual crowd
  - Behavioural control
  - Rules, scripts

- Virtual human animation
  - Skeleton animation
  - Walking engine
  - Keyframes
  - Animation mixing
  - Skin deformation
  - Face animation mixing
  - Face deformation
  - Speech

- Others
  - VRML, HANIM, XML, MPEG-4, ...
Questions please?