Virtual Reality based Visualization

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Outline of the presentation

• Relationship between simulation, visualization and VR
• What is Virtual Prototyping?
• Functionalities of a Virtual Prototyping Environment
• Our Approach to it: COVISe
• Distributed Environment
• Simulation Integration
• VR-Extension
• Some Application Cases
The Virtual Environment Lab at HLRS

- 3 Wall + Floor Stereoscopic Back Projection System
- Triple Screen and Keyboard Option
- Switch
- Onyx2 Dual Rack System
- 3 x InfiniteReality Pipes
- 14 x R10000 CPUs
- 4 GB Memory
- HIPPI / ATM / FDDI / Fast-Ethernet
- Fiber-Channel/Disk Rack
- Digital Video I/O

How does Visualization fit into Simulation based Problem Handling?

• Pre Processing
  - grid generation,
  - initial/boundary conditions

• Simulation

• Post Processing (Visualization)
  - error detection,
  - feature extraction,
  - behavior analysis
Why does the Role of HPC oriented Visualization increase?

- Improved tools for preprocessing, e.g., for grid generation
- Maximum simulation times stay constant
- Increased complexity of simulation problems
- As result: Change in the duration of processing steps
- Increased importance of human driven analysis phase

Example: Crash Simulation at BMW (relative processing times)

<table>
<thead>
<tr>
<th>Year</th>
<th>Preprocessing</th>
<th>FE-Simulation</th>
<th>Postprocessing</th>
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<td>1991</td>
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<td>1997</td>
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Example: Increased Role of Post Processing in CFD Simulation

Change in processing times for CFD simulation in a car engine

Turnaround times for changes
- M111 engine
- medium-sized mesh (250,000 CV)
- cold-flow

PreProcessing
Calculation
PostProcessing

HPS-ICE Project (data courtesy DaimlerChrysler)
Characterization of a Virtual Prototype

Let’s imagine, an engineer has a prototype of a future product, which

- looks like a real product or at least has recognizable similarities
- allows handling like a real product or even better (no weight)
- has a behavior like a real product
- allows operations like with a real product or even easier (e.g. in dangerous zones)
  - change of geometric parameters, e.g. flow channel diameter
  - change of material properties
  - change of initial and boundary conditions, e.g. heat influx

Functionalities of a Virtual Prototyping Environment

- Scalable user interface from Desktop to Virtual Reality
  - Window systems based 2D user interface + 3D rendering
  - User interface extension into VR rendering environment
  - Web based extension
- Support collaborative and distributed working
- Toolbox (MVE) approach for easy construction of application cases
- Seamless integration of heterogeneous hardware platforms
  - Processes on simulation machines, workstations, VR-equipment
- Distributed data management
- Optimized for high performance environments
  - fast networks
  - Parallel and vector machines
COVISE

- MVE+ MSE
- Simulation and visualization coupling
- Distributed multiprocessing
- Data flow networking paradigm
- Visual programming editor
- Easy extendibility
  - new modules
  - new data types

COVISE Screen Snapshot

COVISE Architecture Characteristics (Single User Mode)

- Central control process
- Separated control and data flow
- Distributed data management
  - Optimized data type conversion
  - Optimized communication rates

Controller
CutGeom
Mapeditor
Renderer

Shared data space
Data object
Module
Data Flow
Control Flow
COVISE Processing Chains

- Seamless hardware integration
- Optimal usage of various servers
  - PVP, MPP, Fileservers, DB-Servers
- Transparent data type conversion
- Handling of firewalls, encryption
  - IP Masquerading
  - ssh
- Alternative communication platforms
  - IP, MPI, ATM

COVISE Collaborative Working Extension

- Basic design for collaborative working
- Separate Map Editor per user
- Processing Pipeline forks to Renderers
- No bandwidth limitation during scene exploration
- Incremental scene changes
- Separate Audio/Video Conferencing
**COVER, COVISE Virtual Environment Renderer**

- Special Render Module using Performer
- Support for Powerwall-, Immersadesk-(TM), CAVE-(TM)like hardware, responsive Workbench, ...
- Close integration with data flow network via feedback protocol
  - Module parameters are defined in VR
  - 3D menu is configured by modules
- Co-operative working in distributed virtual Environments via COVISE communication interface

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**Steering of remote processes from the Virtual Environment**

Application Module
- Create Output Object
- Compute
- Read New Input Parameters
- Read Input Object

Virtual Environment
- Read Input Object
- Extract Semantic Information
- Create 3D Interaction
- Visualize Data
- Wait for Interaction

 Feedback Message

Data Availability Message
Virtual Prototyping: Controlling all steps in Virtual Environment

- Geom. Generation
- Grid Generation
- Simulation
- Postprocessing
- VR-Visualization

Testcases of EC Project VISIT (Virtual Intuitive Simulation Testbed)

- DaimlerChrysler
- Voith Hydro
- De Pretto Bacher-Wys
- Valmet
- BAE Systems
- University of Jyväskylä
Inlet angle: 20°
No back flow, increased efficiency in draft tube, but decreased efficiency in runner.

Inlet angle: 0° (design point)
Reduced efficiency due to back flow area in draft tube (red).

Virtual Prototyping of Fluid Flow Simulation

Virtual Prototyping of a car cabin

VR-Control of air inlet parameters (Daimler-Chrysler)
Optimisation of a Water Power Plant in Nepal

- Optimisations led to 5% more power output
- Fluctuations of power output have been eliminated

Data courtesy IHS, University of Stuttgart

Water Turbine assembly

- Multiple Parts in one VR space
- Animated Objects

Data courtesy IHS, University of Stuttgart
Stator/Rotor Interaction in a Steam Turbine Stage

- Unsteady simulation of last stage of a transonic steam turbine
- VR usage for improved analysis, e.g. viewer attachment to rotor.

Data courtesy ITSM, University of Stuttgart
SIEMENS Gas Turbines

Analysis of Internal Combustion Engine

- ESPRIT HPS-ICE:
  High Performance Simulation of Internal Combustion Engines
- Parallel Simulation and Visualization in a Distributed Environment
- VR Interaction for Result Analysis

Data courtesy Daimler Benz