Visualization Challenges in CAE

July 28th, 2010
Agenda

Visualization Challenges in CAE
July 28th, 2010
8:00am PDT (Seattle) / 11:00am EDT (New York) / 4:00pm BST (London)

Welcome & Introduction (Overview of NAFEMS Activities)
Matthew Ladzinski, NAFEMS North America

The Role of Visualization in Digital Prototyping and Performance Simulation
Don Tolle, CometSolutions

The Role of Scientific Visualization in CAE
Shawn Zhang, Visualization Sciences Group

CAE Visualization Challenges: VCollab’s Perspective
Joe Walsh, IntrinSim (Representing VCollab)

Q&A Session
Panel
Closing
An Overview of NAFEMS Activities

Matthew Ladzinski
NAFEMS North America
Planned Activities

- **Webinars**
  - New topic each month!
    - Simulation of Variability in the Hybrid 3 Crash Test Dummy – August 25th
    - Practical Approach to Deformation Analysis – November 8th (NAFEMS Italy)
  - Recent webinars:
    - Visualization Challenges in CAE - July 28th
    - Strategies for Deploying Expert and Casual CAE Tools - TODAY
    - Fire Modelling in CFD
    - “Accepted Practices in FEA” (NAFEMS India Webinar)
    - Product Performance Simulation in the Year 2020
    - What is V&V
    - How to Ensure that CFD for Industrial Applications is Fit for Purpose
    - Practical CFD
    - Composite FE Analysis
    - 10 Ways to Increase Your Professional Value in the Engineering Industry
    - Dynamic FE Analysis
    - Modal Analysis in Virtual Prototyping and Product Validation
    - Pathways to Future CAE Technologies and their Role in Ambient Intelligent Environments
    - Computational Structural Acoustics: Technology, Trends and Challenges
    - Practical CFD Analysis
    - Complexity Management
    - CCOPPS: Creep Loading of Pressurized Components – Phenomena and Evaluation
    - Multiphysics Simulation using Implicit Sequential Coupling
    - CCOPPS: Fatigue of Welded Pressure Vessels
    - Applied Element Method as a Practical Tool for Progressive Collapse Analysis of Structures
    - A Common Sense Approach to Stress Analysis and Finite Element Modeling
    - The Interfacing of FEA with Pressure Vessel Design Codes (CCOPPS Project)
    - Multiphysics Simulation using Directly Coupled-Field Element Technology
    - Methods and Technology for the Analysis of Composite Materials
    - Simulation Process Management
    - Simulation-supported Decision Making (Stochastics)
    - Simulation Driven Design (SDD) Findings

To register for upcoming webinars, or to view a past webinar, please visit: [www.nafems.org/events/webinars](http://www.nafems.org/events/webinars)
Established in 2009

Next courses:
- Non-Linear Analysis – July 20th, 2010 (*four-week course*)
- Composite FE Analysis – August 24th, 2010 (*four-week course*)
- Dynamic FE Analysis – TBA (*seven-week course*)
- Simulation-Supported Engineering – TBA (*four-week course*)

Proposed course offerings:
- Optimization – TBA

For more information, visit: [www.nafems.org/e-learning](http://www.nafems.org/e-learning)
Date: TBA
Location: Online (virtual)
Keynote Speakers: Prof. Jim Wood, University of Strathclyde,  
*plus three others TBA in the coming weeks*

Conference Themes:

- Business developments to increase the financial impact of CAE investments
- Technical developments to improve speed, accuracy, reliability, accessibility, and applicability of results
- Human issues (e.g. Teaching simulation as part of the basic engineering curricula, certification, etc.)

For more information, visit: [www.nafems.org/virtual](http://www.nafems.org/virtual)
Date: October 12-13, 2010
Location: Paris, France
Keynote Speaker: TBA
Conference Themes:
- State of the art technologies and applications of digital simulation
- Optimization, robust design and reliability of the products
- Benchmarking, verification and validation
- Economic impacts of simulation

For more information, visit:
www.nafems.org/events/nafems/2010/francecongres
Date: October 26-27, 2010
Location: Gothenburg, Sweden
Keynote Speaker: TBA
Conference Topics:
- Trends and future needs in engineering simulation
- Robustness and confidence of analysis results
- Optimization / stochastics
- Multiphysics / coupled analysis
- Materials
- Nonlinear Analysis
- Plus much more...

For more information, visit: www.nafems.org/events/nafems/2010/NORDIC2010/
Date: May 23-26, 2010
Location: Boston, MA
Current Call for Papers (Deadline: October 18th, 2010)
For more information, visit: www.nafems.org/congress
NAFEMS Events

Multiple opportunities to attend conferences, seminars/workshops and training courses

Let us know if you would like to schedule an on-site training course

For more information, please visit: www.nafems.org
The Role of Visualization in Digital Prototyping and Performance Simulation

July 28, 2010
“A single picture is worth a thousand words”
Widespread Availability of Cheap Computing

- An Osborne Executive portable computer, from 1982, and an iPhone, first released in 2007. The Executive weighs 100 times as much, has nearly 500 times the volume, cost 10 times as much, and has 1/100th the processing power of the iPhone.
Digital Information Access is now global and pervasive...24 x 7 X 365

- Internet and Corporate Intranets access
- Web 2.0 – Communications & Social Media abound
  - Skype
  - Yahoo & Gmail
  - Google Docs
  - Facebook
  - Twitter
  - Wikipedia
  - YouTube
Visualization’s Evolving Role in Product Engineering
Visualization’s Increasing Role in Virtual Prototyping & Design
Visualization’s Role in Simulation: The Industry Challenges

- Explosion of Simulation Data (Too Much Information?)
  - Size & Quantity of both Input Models and Results Files (Terabytes)
  - Need for higher fidelity and complex, cross-disciplinary simulations to adequately predict physics of product performance vs hardware
  - More analysis iterations per engineer with multiple CPUs available
  - Trend towards the use of DOE/stochastic/robust design methods vs the deterministic approach (to deal with variability & complexity)

- Provide design guidance sooner vs. late stage “forensics”

- Enable non-experts to readily understand and consume product design alternatives based on simulation results
Visualization’s Future Role in Virtual Engineering: What can we expect from the vendors?
Visualization’s Role in Simulation: Today’s Industry Presenters

- Visualization Sciences Group (VSG)
  - Shawn Zhang, PhD - Product Leader

- Visual Collaboration Technologies (VCollab)
  - Joe Walsh - President & Founder of IntrinSim
The Role of Scientific Visualization in CAE

Shawn Zhang, Ph.D.
Visualization Sciences Group
Visualization’s Role in CAE challenges

• Visualization = Post-processing
  Post-processing = icing on the cake?

• Visualization > Post-processing
  – CAD
  – Meshing
  – Solver

• Visualization >> icing on the cake
Scientific Visualization: The history
Scientific Visualization: The community

- IEEE Visualization (Viz), EuroViz, PacificViz
- More than 1000 papers published since the 1987 inception
- Vis2009 Section “Time Dependent Data Visualization”
  - Visualization and Exploration of Temporal Trend Relationships in Multivariate Time-Varying Data (The Ohio State University)
  - Isosurface Extraction and View-Dependent Filtering from Time-Varying Fields Using Persistent Time-Octree (PTOT) (Polytechnic Institute of New York University)
  - Visual Exploration of Climate Variability Changes Using Wavelet Analysis (German Climate Computing Centre),
  - Interactive Coordinated Multiple-View Visualization of Biomechanical Motion Data (University of North Carolina)
Scientific Visualization: The research work
Postprocessing VS Scientific Visualization: Vector Plot -- Arrow heads
Postprocessing VS Scientific Visualization: Vector Plot -- LIC
Postprocessing VS Scientific Visualization:
Tip vortex study: Streamline
Postprocessing VS Scientific Visualization: Flow feature extraction
A more active role of scientific visualization: motivation re-iterated

1. CAE data has grown larger, CAE problems are getting complex and cross disciplinary

2. Associated visualization problems are not readily addressed by CAE practitioners either due to expertise constraints or due to resource constraints

Results:
Challenges unmet or under-met
Key to success

Common framework for CAE users to address common challenges

Benefit

- Graphics hardware and API evolution made transparent
- Cross platform and cross display supported
- Common visualization algorithms developed and maintained once for all

These will allow CAE developers to focus on core competency by avoiding re-inventing the wheel, and provide the CAE customers with shortest path to best visualization performance and quality
Common Data Interfaces

1. Uniform data storage
2. Federating multiple data sources
Federating different data sources

Simulation formats
- FEA formats
  - Abaqus, Ansys, Nastran
- CFD formats
  - Fluent, Star-CCM+
- Multiphysics formats
  - Comsol, Ansys multiphysics
- Crash simulation format
  - Madymo, Radioss
- Scientific Data Formats
  - Matlab, Tecplot, AVS
- Climate simulation formats
  - NetCDF
- Molecular simulation formats
  - PDB, AMBER, CHARMM, PHI, TRIPOS

Modeling and Experiment Formats
- 3D Scene/Geometry and CAD Formats
  - VRML, Open Inventor (.iv), DXF, IGES, STEP CATIA...
- 3D imaging (MRI, CT, FIB-SEM)
  - TIFF, JPG, PNG, BMP, RAW Binary... DICOM
- Microscopy Formats
  - Leica, Zeiss, Bio-Rad, FEI, MRC, STK...
- Surface Scanner Formats
  - PLY, PSI

Customizable with modern programming/scripting
Common Large Data Processing

• Parallel data extraction
• Parallel rendering
• Remote visualization
• Co-processing
• Feature extraction

Common utilities

• Data compression
• GPU computing
• Usability, interactivity
• Collaboration and presentation
• Framework openness: extensible, automation
Feature extraction

Technologies: Vector Field Topology, GPU Acceleration

**Benefit:** Automatic identification of ROI, data reduction, interactive exploration of large data
Parallel rendering

**Technologies**: multi-GPU, Tile and depth decomposition

**Benefit**: Rendering large scene with possibly trillions of data elements; Supporting high end visualization systems

Tiled Display Case  
Immersive Cave Case

Data courtesy LCTS

University of Birmingham
Co-processing

- **Technology**: Common API access; data extraction; data communication
- **Benefit**: Data reduction; Real-time visualization

Avizo-Matlab Bridge  
Avizo-LabVIEW Bridge
Remote visualization

- **Technologies**: GPU acceleration on client and server; Compression
- **Benefits**: Large or confidential data; Share high performance resource…
GPU Accelerated Visualization

**Technology:** GPU Computing to CAE applications

**Benefit:** Interactive exploration of large amount of data; take full advantage of existing GPU power for both visualization and computing.
From Image to Simulation

Metrology: CT->Stress Analysis

Rock pore analysis: FIB/SEM->Porous flow analysis

Corn drying: MicoCT->Multi-physics

Aneurysm blood flow: MRI->Flow analysis

Comsol Conference, 2009
Conclusion: Open is the key

• Open framework
• Open discussion
• Open mind
Challenge us

• Can you do better?
Acknowledgement

• NAFEMS
• All visualizations are generated with VSG technology by VSG or VSG Customers
• Some research results are documented in Physics of Fluids and Conferences Proceedings organized by AIAA, NAFEMS, Comsol and Nvidia

Contact

• shawn.zhang@vsg3d.com
• www.vsg3d.com
CAE Visualization Challenges: Vcollab’s Perspective

Visual Collaboration Solutions
VCollab Overview

• VCollab established in 2000
• VCollab HQ at Troy, MI
• Develop and market VCollab brand of Software Solutions
• Currently 3 out of 5 major Automotive OEMS are using the VCollab solution as the visual collaboration platform for sharing CAx (modeling & simulation) data

• VCollab provides a common light-weight CAE Data Visual Collaboration platform i.e. “pdf for CAE”
CAE Visualization Challenges

- Data, data, and more data, and then even more data
  - Many CAE applications and many formats
  - CAE results files are very large
  - Increased usage of CAE is dramatically increasing the number of simulations and large result files
  - Higher level tools (DSE, Systems Engineering, Robust Engineering, stocahstics…) will cause data to explode
CAE Visualization Challenges

• CAE data is complex and varied
  – Many CAE applications and many formats – no standard
  – Complex field results for different physics
    • Solid Mechanics
    • Fluid Mechanics
    • ElectroMagnetics
    • Acoustics
    • Others …
  – Transient results
  – 2D images are not enough
  – 2D movies are not enough

• Data files are HUGE !!!
CAE Visualization Challenges

• Multiple use cases for CAE visualization
  – Expert interactive review
  – Report generation
  – Simulation review (peer & management)
  – Presentation & collaboration
  – Data Archival
  – Integration with PIDO / SLM and other processes
VCollab Perspective

• Focus on complex 3D transient CAE Data being accessible broadly
  – Significant visualization required beyond expert usage
    • Need support for presentation/communication and simulation reviews
    • Need support for automated reporting
    • Need support for archival
  – Large number of iterations required for high end processes (ie design space exploration, systems engineering, SLM, …)
    • Significantly reduced data size with accuracy is critical
VCollab Perspective

- **Need for universal compact CAE format**
  - Typically need 95% or greater compressions rates

- **Need for CAE data reduction tools to create compressed files**
  - Support for leading CAE software
  - Support for in-house codes
  - Support for less used and specialty codes

- **Need for automated metadata extraction**
VCollab Perspective

• Need for easy to use, professional, light weight CAE Viewers
  – Basic viewer
  – Advanced viewer for data exploration
  – Professional viewer for Modification of compressed data

• Need for interfaces with general tools
  – Internet Browser
  – MS/Office
  – MS SharePoint
VCollab Perspective

• Need for integration with PIDO / SLM solutions
  – iSightFD – now part of DS SLM offerings
  – ANSYS EKM
  – Siemens – TeamCenter for Simulation
  – Others …
VCollab Approach

- Focus on non-interactive CAE Visualization usage
  - Provide universal compact CAE format (.CAX)
  - Provide CAE data reduction tools (VMOVE) to create CAX files
  - Provide Easy to use, professional, light weight CAE Viewers (VCollab) with interfaces with other tools
  - Provide community for sharing analysis results

- Make complex 3D transient CAE Data broadly accessible
Questions

Website: www.nafems.org
Thank you!