Combined Visualization

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Summary

In recent years there has been an increased focus on combining simulation results from different engineering disciplines. In addition, results from experiments are frequently used to improve and calibrate simulation result. As a result, the need for advanced 3D visualization tools has emerged. Powerful tools for combining, visualizing and inspecting simulated and experimental data increases the understanding of complex physical phenomena. Combining data sets is often a time consuming process including handling of very large amounts of data in different formats and resolutions. The functionality of the 3D Visualization tool, GLview Inova, has been extended to deal with combined visualization, and include advanced features for data interpretation which gives the engineer the opportunity to focus on understanding the content of the data.

The focus of this presentation is to discuss and demonstrate tools and methods to visualize data from different application areas in ways that allows the user to compare data from different sources directly and interpret and understand them. The topics that are covered are:

- Visualization of data from coupled analysis
- Visualization of simulated data and measured results in combination
- Future development of multi-discipline visualization

During the presentation, free, lightweight tools to facilitate better understanding and communication of multi-discipline problems will also be demonstrated.

1 Preface

In recent years there has been an increased focus on combining simulation results from different engineering disciplines. In addition, results from experiments are frequently used to improve and calibrate simulation result. As a result, the need for advanced 3D visualization tools has increased. Powerful tools for combining, visualizing and inspecting simulated and experimental data increases the understanding of complex physical phenomena.

2 Visualization of data from coupled analysis

This presentation takes a closer look at four main areas where visualization of data from coupled analysis is especially useful:

1. Control of coupling parameters at setup
2. Monitoring of coupling progress
3. Post-processing of results
4. Presentation and communication of engineering results

Ceetron has had the opportunity to work with Fraunhofer SCAI to develop the new MpCCI Visualizer (see figure 1), which recently was released in version 3.1. This is one example of a tool that is very useful for visual inspection of the coupling parameters (alignment, mesh fit etc.) that can be performed before the actual analysis is started. The MpCCI Visualizer will enable the user to verify the consistency of the coupled models before a time-consuming job is started and hence save time and money by avoiding setups with a bad fit.

In its next release, the MpCCI Visualizer will include on-line monitoring capability to monitor the analysis as it is progressing. This will enable the user to control that the analysis is progressing as planned. Again, this enables the engineer to save time and money by interrupting an analysis that is not progressing as expected, for whatever reason, at an early stage.

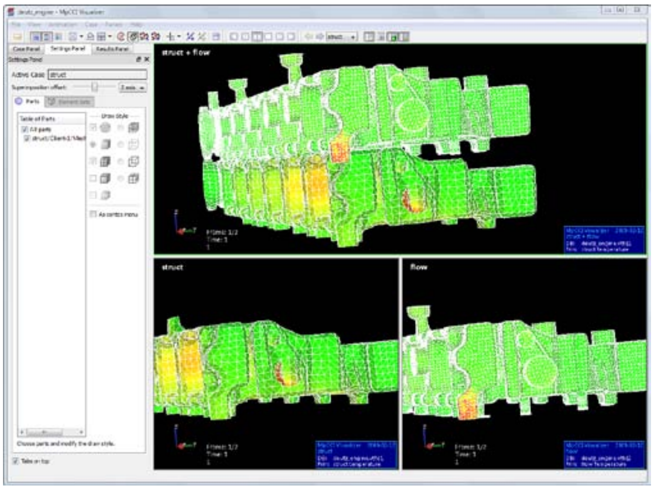


Figure 1: Inspection of coupling parameters using MpCCI Visualizer

This presentation will proceed to look at how the outcome from a coupled analysis can be post-processed and then presented to relevant stakeholders.

Most simulation codes today come with their own post-processing software, which is well tailored to post-process the output from that simulator. However, what most of these tools are lacking is the ability to read and post-process data from other sources – especially if the other source is from another domain (i.e. FEM and CFD for a FSI problem).

There are some general purpose post-processors available on the market, which will allow you to overcome this problem – one of them is GLview Inova (see figure 2), built on the same technology as the MpCCI Visualizer. A short demonstration of the advantages of being able to combine two datasets in one post-processor will be given in the presentation.

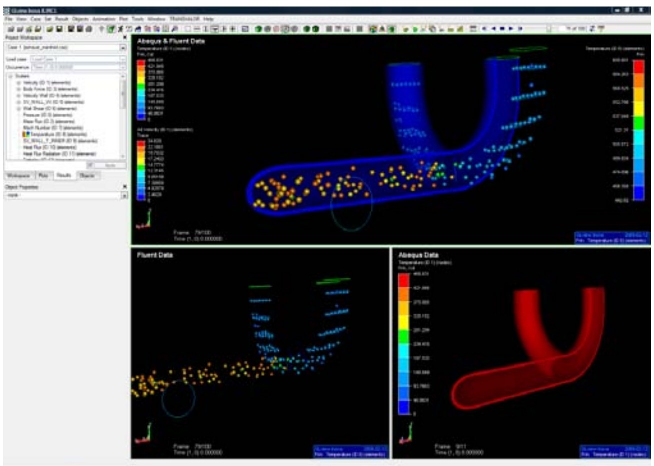


Figure 2: Post-processing data from multiple sources in GLview Inova

2.1 Further development

Features to make it easier to work on superimposed cases will improve usability.
For instance,

- Ability to add cut-planes that intersects all geometries in a view
- Ability to change or modify units to align and compare results from different sources having different scaling and units
- Functionality to work with mirroring (symmetry) and feature extraction
- Extended features for synchronization of time series and animations

2.2 Presentation and data sharing

For the engineer, there always comes a time when the outcome of the job done needs to be presented to stakeholders in the project or discussed with colleagues. Known challenges at this stage is transporting or accessing the large datasets needed to visualize the data, getting a token to the application needed to do the visualization, or making enough images and animations available to be able to discuss the problem.

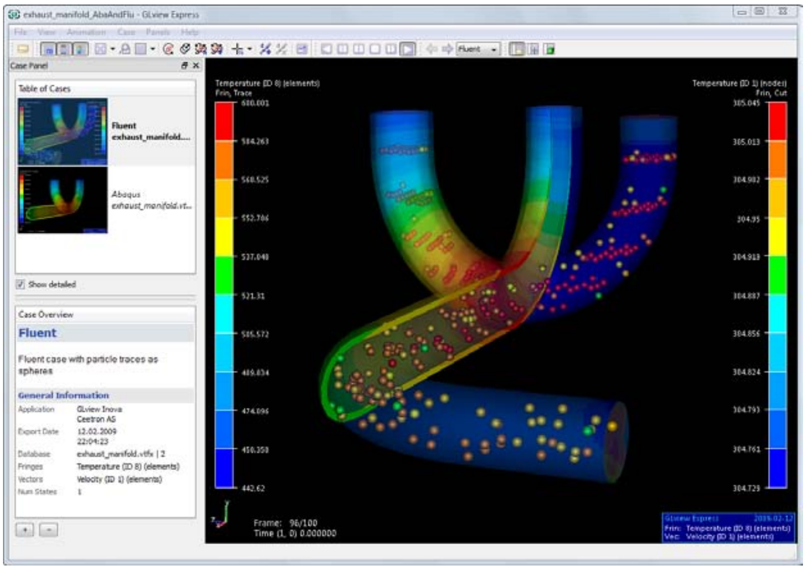


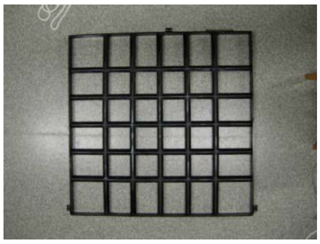
Figure 3: Multi-case visualization in GLview Express

For this purpose, the models, the selected results and any feature extractions applied, can be exported to a very compact and efficient file format that can be viewed in free viewers. The free viewers enable interactivity like zoom, pan and rotate, result picking, as well as the ability to run animations. A short demonstration of the use of GLview Express and the GLview 3D Plugin will be given during the presentation.

3 Visualization of simulated data and measured results in combination

Another area where combined visualization has clear benefits is when one needs to compare simulated data with measured results from experiments.

In the example that will be used in this presentation, the Norwegian aquaculture industry are doing a study of the flow through and around fish aquaculture cages. The cages are situated in open water and are subjected to currents, and thus the vortex shedding behind the individual cage elements would influence the position and structural integrity of the structure. The flow downstream of a single cruciform conguration is characterized by a large cross shaped wake, with the wake becoming more two dimensional as you move away from the cylinder intersection. An aquaculture cage consists of many such elements, and thus a grid of intersecting cylinders was chosen to replicate the effects of these multiple elements. The flow behind the intersections thus is highly turbulent with a combination of horizontal and vertical wakes in the vincinity of the cylinders [1].



A PIV (Particle Image Velocimetry) experiment was conducted at the Marine Cybernetics towing tank facility (MCLab) at The Norwegian University of Science and Technology (NTNU), Department of Marine Technology in Trondheim, Norway. The simulated results for comparison are produced at the same department.

The PIV experiment uses lasers to illuminate particles that are released into a water flow, and two digital cameras are used to capture the movement of the particles – in this case at a frequency at 10Hz. PIV is a non-intrusive technique (in the measurement plane of interest), and depending of the setup used, can measure all three velocity components of the velocity vector. By correlating two consecutive images, velocity vector maps of the instantaneous flow field are obtained as ASCII data and visualized using any standard visualization package.

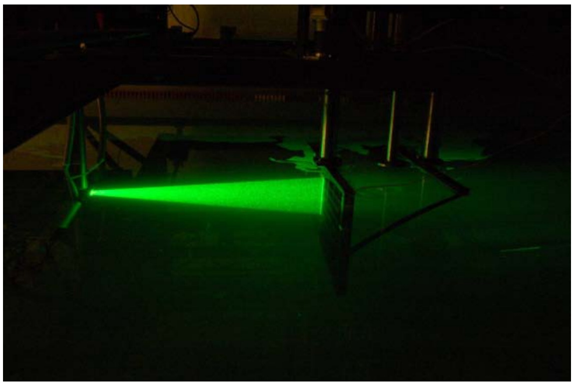


Figure 4: Picture from the experiment

In the MCLab, a carriage is moved in the X-direction, and has a maximum velocity of approximately 0.8m/s, but has been tested to run at speeds as low as 0.01m/s. For the current experiment, a 3x3 grid of cylinders was used. The diameter of the cylinders was 32mm and the spacing between cylinder centers was 220mm. The carriage with the PIV setup was towed down the tank at a speed of 0.1m/s. This gives us a Reynolds number based on diameter of approximately 3200 (equal to the full scale Re number).

As can be seen in figure 5 the velocity vectors are similar to that which can be obtained from numerical simulations of flow fields.

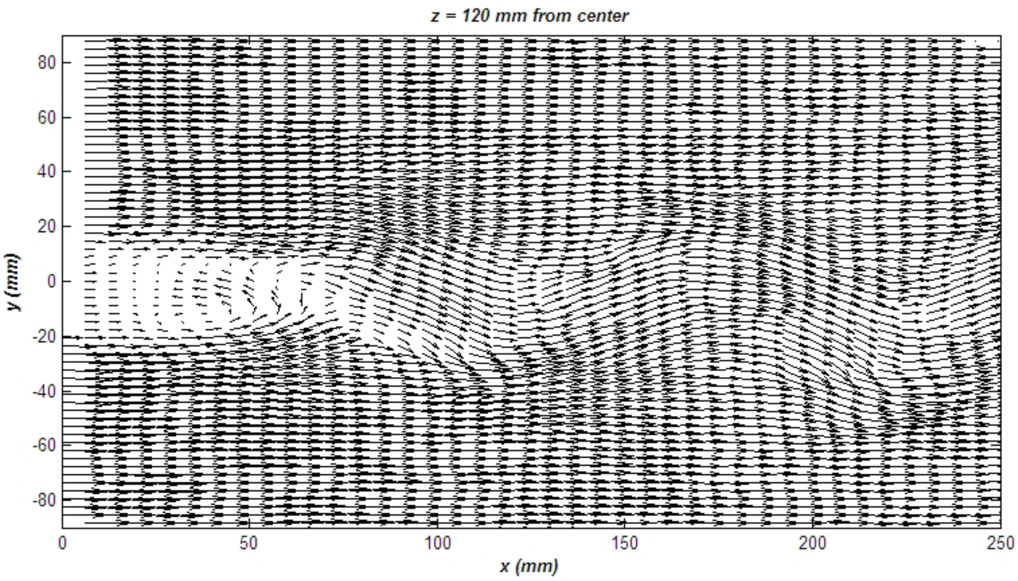


Figure 5: Velocity vectors downstream of the grid of circular cylinders as obtained from PIV experiments and visualized using the commercial Matlab software package. Here the flow is from left to right and the cylinder is at (x; y) = (0; 0)

The simulated results in this example were obtained using Gerris Flow Solver (http://gfs.sourceforge.net/wiki/index.php/Main_Page). An adaptive mesh of quadrilateral cells is utilized. The Reynolds number based on diameter was 1250 for the simulations, and no turbulence model was applied to the computational scheme. The challenge that then arises is how to compare the two data sets (experimental and computational) efficiently and effectively.

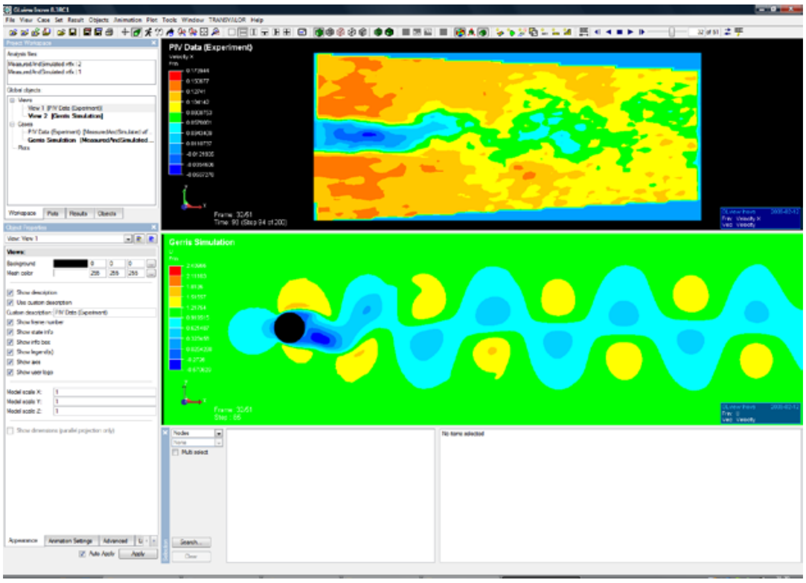


Figure 6: Post-processing simulated and measured results in GLview Inova

The data sets from the experiments and computations are in two different formats, and time steps. The usual method of comparing data sets would be to convert the sets into a common format that can then be visualized in whatever manner one chooses. However, the quantity of data involved is quite large, and thus the procedure is very time consuming when trying to obtain comparisons. To that effect, Ceetron AS have developed their GLview visualization program to very quickly and efficiently read both the PIV and CFD data and provide comparisons both visually and quantitatively in an easy user friendly package. A screen shot of the tool can be seen in figure 6. Visible in figure 6 is a comparison between the experimental (top) and computational (bottom) results highlighting the differences and similarities of the flow field.

A short demonstration of how GLview Inova can be used to post-process a combination of simulated and measured results will be given during the presentation.

3.1 Further development

The following features are identified as potential enhancements, to make the tool more powerful for post-processing measured results.

- Extending the PIV dataset to full 3D
- Visualization of other measured results (may not be as straight forward as the example shown)
- Change of units in dataset to facilitate direct comparison of data from different sources
- Synchronization of time-steps and animation
- Support for combining Video and Simulated Results
- Features for alignment of geometries

4 Acknowledgements

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5 References

[1] C. Muthanna, J. Visscher and B. Pettersen. Investigating Fluid Flow Phenomena behind Intersecting and Tapered Cylinders using submerged Stereoscopic PIV, 14th Int. Symp. On Appl. Laser Techniques to Fluid Mechanics, Lisbon, Portugal July 07-10 2008.