COVISE and the Virtual Intuitive Simulation Test bed

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Abstract

This paper describes the developments performed in the EU-project VISiT (Virtual Intuitive Simulation Test bed). The goal of the project is the development of an intuitive simulation test bed based on Virtual Reality technology. As a new man-machine interface it will be an efficient environment for a small team of engineers and designers, that enables also the designer to evaluate and interact with the complex 3D data of simulations. The basis of the Virtual Intuitive Simulation Test bed will be COVISE, an extendable distributed software environment to integrate supercomputer based simulations, post-processing, and visualisation functionalities with co-operative working in a seamless manner. The project covers different application fields, including heating, ventilation and air-conditioning simulation in a passenger car compartment and the flow simulation in a draft tube and in an axial runner of a water turbine.

1 The Project

VISiT is an Esprit-project funded by the European Commission under the contract No. 28247. The goal of the project is the development of the interactive 3D-simulation environment VISiT by using Virtual-Reality techniques (VR) and HPCN tools developed already in other research projects. By bringing together end-users from different industries it is ensured that the VISiT environment can be effective independent from the application field.

The project-partners are BAE Systems, DaimlerChrysler, De Pretto-Escher Wyss, ICEM CFD-Engineering, University of Jyväskylä, University of Stuttgart, Valmet, VirCinity and Voith Hydro. The project started in 1998 and will continue until September 2001.

2 The Problem

The use of HPCN-technology enables industry to shorten the development time by reducing the computational time for numerical simulation considerably. The limitations for efficient use now comes from insufficient through-put by pre- and post-processing time. The time to evaluate the huge amount of 3D data produced by numerical simulation and the time to redefine or to modify boundary conditions for derived simulations are the critical bottle necks, that hinder the efficient use of simulation within the first phase of design, where fast and frequent changes or modification of the components are inherent in the process.

The whole process of the pre- and post-processing for one of the test cases is shown in figure 1. In the post-processing phase the use of Virtual Reality technology by the end user partners is already established and growing strongly. It allows the users for example to directly put particles into a velocity field similar to a wind tunnel experiment. In the VISiT project this use of VR-technology shall be extended to all simulation relevant phases in the development cycle, not only making it possible to change boundary conditions (i.e. temperature for a car climate simulation or velocity for a turbine simulation) but even some well-defined geometry changes can be performed in the Virtual Environment with a really quick update of the numerical solution.

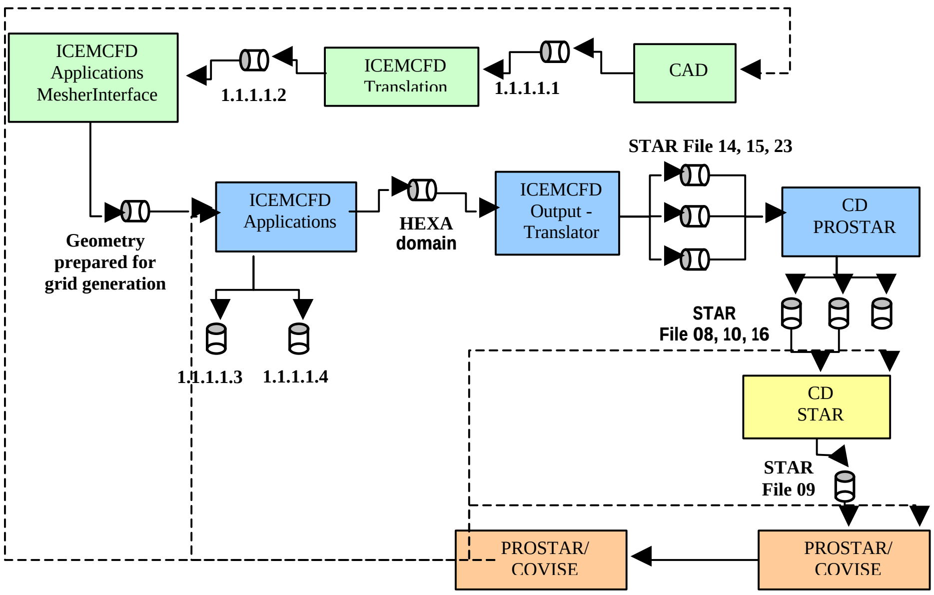

Fig. 1: The VISiT scenario

3 The Integration Platform

3.1 The COVISE Software

In the VISiT project the COVISE software has been chosen to implement the complete Virtual Environment for the analysis of numerical simulations. The COVISE approach of modular components that are based on a distributed infra structure and that are directly connected to a Virtual Reality front-end makes it very easy to integrate all the pre- and post-processing steps into a homogeneous working environment.

In figure 2 the overall architecture of the COVISE visualisation system is shown. Basically it can be structured in two parts: the basic infra structure that contains the functionality for distributed and collaborative working and the modules that are based on this infra structure and implement the actual visualisation functionality. The Virtual Reality functionality has been realised as a front-end that has been tightly integrated: an Iris-Performer based renderer can be used in addition or instead of the desktop renderer. Through a feedback loop the interaction between the user and the visualisation modules is handled.

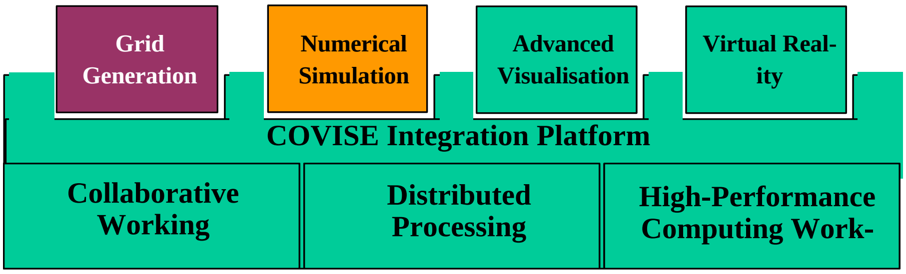

Fig. 2: COVISE System Architecture

3.2 On-Line Simulation Coupling

Since several years modules cannot only provide visualisation functionality but it is also possible to integrate numerical simulations into the platform. In 1998 a coupling to the commercial solver Star-CD has been established to directly influence the boundary conditions of a car climate simulation by changing the direction of the air vents or the air temperature.

The main difference to other projects that are working in a similar direction is, that this is no longer a proprietary coupling to a well-known simulation code whose sources are available to the project. Instead the VISiT project covers both, proprietary source code based coupling as well as the integration of commercial simulation codes into the visualisation environment. This is handled through the COVISE SimLib that has especially been designed to interface with simulation codes based on concepts like the “user subroutines” that Star-CD provides.

3.3 Integration of the Grid Generation

In the VISiT project the integration capability of COVISE is now utilized to allow the modification of the geometry to a certain extent. In a first step the geometry modification can be the movement or replacement of a sub grid that is overlaid to a basic grid. In further steps this functionality will be developed continuously to allow an ever more integrated approach to the optimisation of the product in the virtual environment.

Similar to the numerical simulation the grid generation in the VISiT project is not only based on proprietary software developments for which the source code is available, but on a commercial grid generator. The project partner ICEM-CFD has integrated its automatic grid generator Hexa as a COVISE module into the integration platform. The generic feedback loop between the Virtual Reality front end and the grid generation module allows then the intuitive control of the Hexa module.

4 The Test Cases

In order to show that this technology can be applied to many application fields, various test cases have been defined by the industrial project partners. Each partners test cases are especially chosen to reflect the important requirements of the partners. Here three of these test cases are presented:

4.1 The DaimlerChrysler Test Case

The test case provided by DaimlerChrysler is a heating, ventilation and air-conditioning (HVAC) simulation in a passenger car compartment. Normally the effectiveness of the HVAC system is evaluated with the help of measuring heating and cooling performance, of air temperatures in the cabin and by assessing personal thermal comfort votes in wind tunnel field test. To reduce the time for testing the numerical simulation is getting greater importance to investigate different cabin designs before any prototype has been build.

The VISiT result will allow the automotive engineers to simulate in an intuitive way the behaviour of the complete system under different conditions. Geometry modifications here can mean that the effect of moving the seat back or forth can be examined directly. A good climatic environment for a large person can quickly be verified for a smaller person by replacing the large body by a significantly smaller one. The location of air vents can be modified easily by simply grabbing one and moving it to the new place. Interdisciplinary teams can very quickly discuss various options from different points of view.

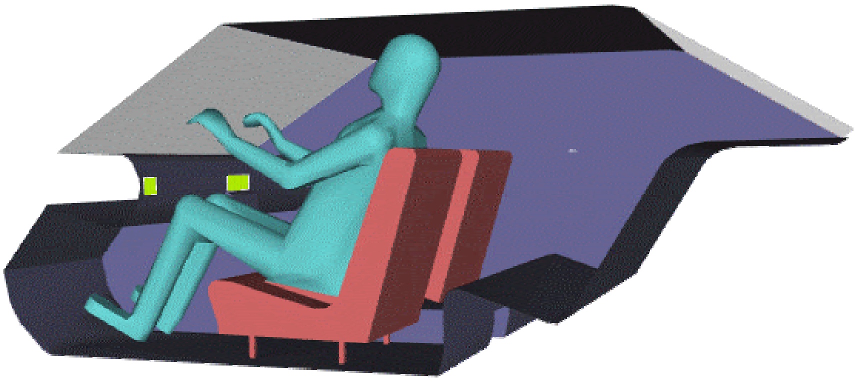

Fig. 3: DaimlerChrysler Model Car Cabin

4.2 The Voith Hydro test cases

These test cases are a draft tube and an axial runner of a water turbine. In a water turbine the runner together with the generator converts the kinetic energy of the fluid into electric energy. The main task of the draft tube is to guide the water from the runner to the tail water transferring the remaining kinetic energy of the flow into pressure. In the ideal case the only kinetic energy remaining in the flow is the one needed for the mass flow to leave the machine.

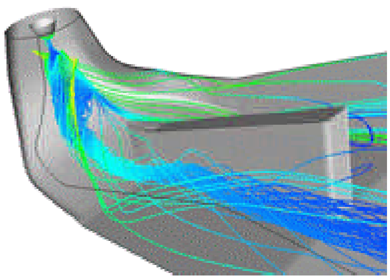

Fig. 4: Voith Hydro Draft Tube

Very important for the costs of a draft tube are the dimensions, and so one of the goals is to keep it as short as possible and to reduce the required depth to a minimum. These requirements always lead to difficult flow phenomena and the VISiT environment should enable the designer to find the optimum based on his intuition and a high quality design tool. The virtual reality environment allows the engineers to directly interact with their design while they get an immediate feedback of the effects of their changes.

4.3 The De Pretto Escher-Wyss Test Case

The test case provided by De Pretto Escher-Wyss is a Francis Turbine Runner. The design of the components of a hydraulic turbine has several goals: first the turbine efficiency and the power output have to be optimised according to the customer conditions. This has to be flexible enough to be useful for several operating points (part load, optimum, full load) and an overall weighted machine efficiency must be guaranteed. For the runner, cavitation must be prevented or at least minimized, for water resources with high particle content the effective erosion has to be minimized.

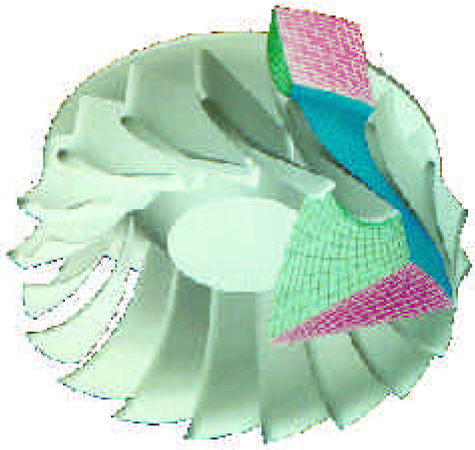

Fig. 5: De Pretto Escher-Wyss Francis Runner

The performance of a Francis runner is influenced by many parameters, e.g. the global runner dimensions, the volume flow rate, the inlet velocity profile or the meridional runner passage geometry and the blade geometry (profile, angles, etc.). All these parameters are input parameters to a special grid generator that very quickly generates a new grid for this special kind of geometries. Geometrical parameters can be changed directly at the geometry in the virtual environment, non-geometry related parameters are accessible via a 3D menu as well as through the standard window based GUI.

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2. Rantzau D. ; Lang U., "A Scalable Virtual Environment for Large Scale Scientific Data Analysis", in: *Future Generation Computer Systems 14 (1998*), pp. 215-222, Elsevier Science, 1998