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On the Use of Virtual Reality Techniques in Electromagnetic Finite Element Simulations

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***Abstract*—Designing electromagnetic devices is an iterative process. To reduce development time and costs, prototyping is preferably replaced by simulations. Both, the models used and the simulation hardware are becoming more and more powerful. 3D techniques are widely used. This results in large amounts of data that need to be regarded and evaluated. Using Virtual Reality (VR) techniques allows to take deeper insight into the solution of complicated 3D simulation results. This paper introduces a visualization software with VR capabilities, discusses the software design, and the use of these techniques both for the design process and for teaching purposes.**

Introduction

The iterative design process for electromagnetic devices is sketched in Fig. 1. Following the idea, a design is generated by the engineer. This is then translated into a model on a computer, in order to perform a simulation. The simulation results are represented, leading to an insight process by the engineer, which eventually will result in new or modified ideas and designs. To accelerate this process, faster simulation methods and faster computers will only result in a shorter simulation time. But still, the communication between the human being and the machine is not improved. To achieve this, all of his input and output channels, his senses, should be used. This is the goal of VR. The use of these techniques is increasing over the last few years, although applications in the electromagnetic field simulations are rare (e.g. [1]).

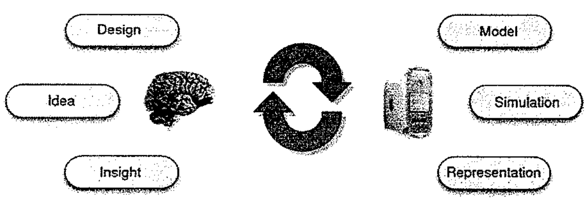

Fig. 1. Design Loop.

Using the finite-element simulation software iMOOSE [2], which already includes a graphical post-processor [3], and with the use of other software packages, a VR-System is introduced. It allows to display and manipulate the solution data of finite element simulations. The software structure is described, and the results show new visualization possibilities. This paper gives an overview of the employed techniques and its potentials.

Implementation

iMOOSE [4] is an open-source environment for Finite Element simulations. The class library includes element classes for different 2D and 3D element shapes and types, problem-definition classes and equation-solving methods. It is programmed using the object-oriented paradigma. This makes it easy to interface to other libraries.

The visualization tool is built around a Python interpreter [5], giving the user full control over all features both in an interactive and scripted way. The visualization routines are delegated to VTK [6], a free Visualization ToolKit. VTK is also used by the virtual reality toolkit ViSTA [7], which generates the virtual world and handles the input devices and the control of the different output devices. The interaction of these software components is depicted in Fig. 2.

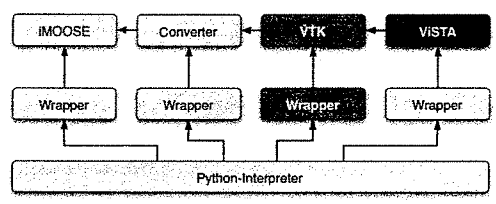

Fig. 2. Software blocks and their relations

For the first tests, a "holobench" is used as the visualization device, which gives a true stereovision effect. The principle of operation is shown in Fig. 3, the real device in Fig. 4. Two projection surfaces each generate two pictures for each of the eyes of the user wearing "shutter glasses". The glasses are equipped with a motion tracking device, to adjust the visualization according to the position of the user's head. This is a great advantage of using VR techniques, since it allows the user to change the perspective by moving his head and "look around" the model. This results in a more realistic perception of the model by generating a true 3-dimensional view.

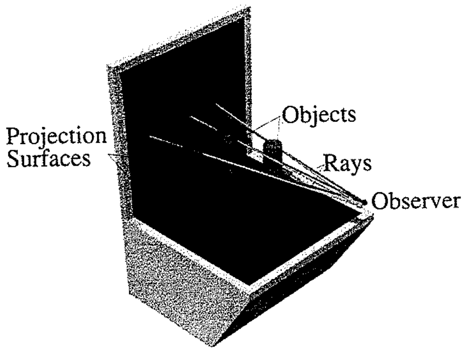

Fig. 3. The Holobench: Principle of Operation.

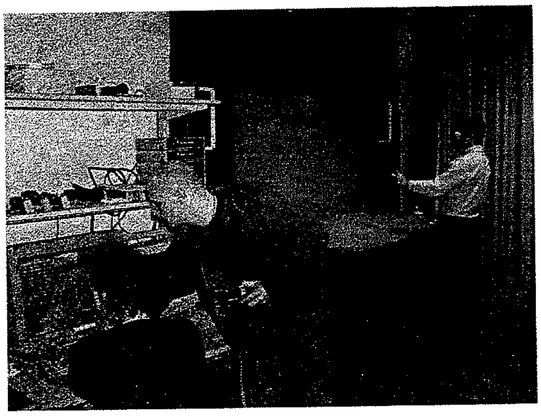

Fig. 4. The Holobench in the VR Lab.

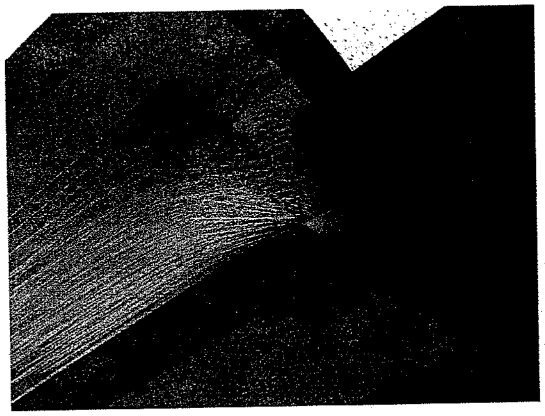

Fig. 5. Hedgehog display.

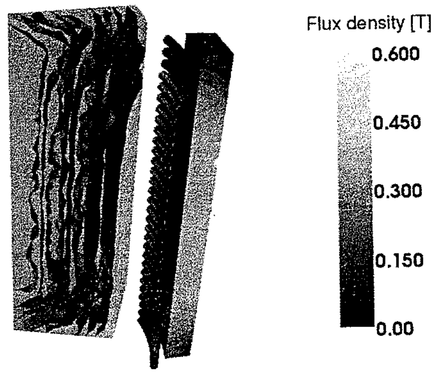

Fig. 6. Iso-Surfaces.

Results

The use of VTK for the representation of electromagnetic field solutions allows for new visualization methods, like the hedgehog display (Fig. 5), simulating a sort of 3-dimensional field lines, or the possibility to generate not only 2-dimensional isolines, but also 3-dimensional isosurfaces of e.g. the magnetic flux density, such as shown in the melt of an induction furnace (Fig. 6). The application of these methods gives the possibility to display and understand complicated 3-dimensional field distributions. This is important for inherently 3-dimensional designs, such as transverse flux machines or claw-pole alternators, where a projection technique to display the field lines does not give satisfactory results, or for complex geometries and field distributions, e.g. in the end windings of generators. But also for teaching purposes, VR can help students to better understand the working principles of electromagnetic fields.

Conclusion

The application of Virtual Reality techniques to the design process of electromagnetic devices is presented. The introduced software allows to represent complicated 3-dimensional simulation results using VR hardware.

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