Digital Libraries & 3D Documents

Generalized digital documents is a research line that focuses on library science issues in the context of three-dimensional models. It has been possible to store text, graphics, images, audio and videos in digital libraries for quite some time. Recently, more and more 3D animations and models have been joining the mix. These different types of data records are often handled separately and processed using different tools. For these differing types of digital documents to be used effectively, however, the users must be given tools with which they can handle the documents uniformly and recognize the ways in which they complement each other. Therefore, it is necessary to create *interconnections* between the individual document forms. The 3D models stored in the database have to be linked with the text, images and videos that reference them, but often this still has to be done manually. Instead, software should automatically recognize related meanings and create the right links (semantics). In this context one can also speak of "three-dimensional" documents (3D documents).

This development of 3D documents has involved challenges that we have successfully taken on for many years. The key here is to develop the necessary algorithms and tools and to generate open standards that permit simple data exchange between a wide variety of digital information types.

Our focus on digital libraries and 3D documents started in 2006 with a Strategic Initiative of the German Research Foundation for digital libraries. From 1997 to 2005, the overall goal of this strategic initiative, called "Distributed Processing and Delivery of Digital Documents," was to research and develop new technologies for creating, distributing and applying electronic information that would then be used to set up digital libraries. It covered three key areas of research:

1. Creation, management and delivery of multimedia digital documents,
2. Networks, compression and data transmission,
3. Multimedia teaching and learning systems.

Since 2006, the German Research Foundation funded the competence center 'PROBADO', which has set itself the goal of integrating 3D models and music into a library system's overall workflow.

Figure 1: digital libraries allow interconnections of information from different 3D documents

Projects Involving Digital Libraries

As director of Fraunhofer IGD, the world's leading institute for applied Visual Computing, and head of the Graphical-Interactive Systems department (GRIS) at the Technical University of Darmstadt, Professor Fellner has initiated a wide range of important international projects in the field of digital libraries. Solutions being developed there set standards. Here is a small selection that provides an overview of the institute's expertise.

VisMaster CA: Rescue from Information Overload

Each day companies experience an almost endless stream of information flowing into their databases. On the one hand, intelligent use of the available data and the information extracted from it offers enormous potential for technological advances and financial success. On the other hand, users and analysts are faced with the serious risk of getting lost in irrelevant or inappropriate presentations of information. This problem is called "information overload." To reach their objectives, companies want to use information that is relevant to them as effectively as possible. For day-to-day operations, Business Intelligence programs collect, evaluate and display relevant data. But many of the existing analysis methods confine themselves to presenting information in static lists and reports. Visual display technologies help to present this information so it can be seen more easily by human beings.

Visual Analytics utilizes the connection between analysis methods and visual display technologies. The basic idea is to meaningfully combine the strengths of intelligent, automated data analysis with the analytical skills of humans. This is done by maximizing the use of human perception. For example, large quantities of numbers are normally presented in tables. Today's solutions display a mosaic of colored cells. When a particular column of numbers deviates from the rest of the data, its coloration or structure immediately draws attention to it. Users can focus on recognizing patterns and then evaluating data more precisely. This makes it possible to recognize connections that would otherwise often go unnoticed. The result is a more reliable decision-making process.

Figure 2: Visual Analytics is a new discipline that develops technologies for producing maximum benefits from huge quantities of information in a variety of applications.

The EU has recognized the importance of Visual Analytics to the European economy by launching the VisMaster CA project. Under the direction of Fraunhofer IGD, 26 European partner institutions from the world of industry and research, including IBM and SAP, are working on new approaches to managing the flood of information.

VisMaster is a coordination project designed to bring together academic and industrial R&D experts and form a community for Visual Analytics in Europe. VisMaster is drawing up a European Visual Analytics research roadmap while bringing Visual Analytics technologies to the attention of decision makers in both the public and private spheres. This will lay the foundation for greater support of Visual Analytics within the European research landscape.

3D-COFORM: World Culture is going 3D Digital

Printed catalogues with photographs and written descriptions of museum exhibitions are the standard of today. Taking a look into the future on a display screen, one can watch Michelangelo's David statue and other masterpieces rotate around their axes in 3D to get an idea of what this project's researchers are developing: a virtual archive of the world's works of art. Vases, historic spears and entire temples are safeguarded this way in three-dimensional form.

This virtual collection is particularly intended to make it easier for scientists to find reference objects that are stored in museum archives but have otherwise been forgotten. Intelligent software can be instrumental in showing, for example, all 6th Century BC Greek vases with at least two handles. Moreover, information about surface condition or the state of a color can also be collected and retrieved in three-dimensional form. As the David statue shows, we already have impressive 3D animations of works of art.

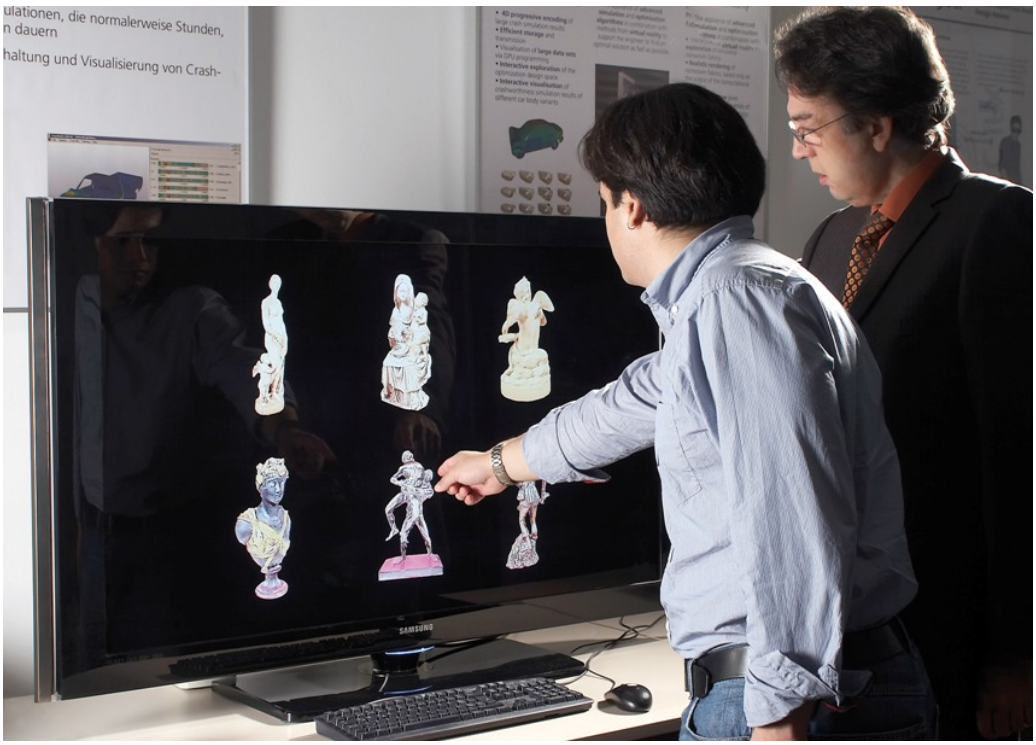

Figure 3: Project 3D-COFORM, which is a European consortium, is collecting works of art and museum exhibitions in a digital archive in three-dimensional form. This is being done to make it easier for researchers to find suitable reference objects and also offer lay persons a fascinating 3D show.

The 3D models for the digital archive are prepared at Fraunhofer IGD. Initial 3D recording is nothing more than a cloud of data points. A true likeness of the object only arises when these data points are reworked. In the future, certain structures such as the arms of statues, columns of buildings and recurring patterns on vases will be recognized automatically and will also be stored as high-level structures. A proper virtual presentation also includes an accurate rendition of detail, such as, for example, the play of shadows around a temple column. To achieve this, Fraunhofer IGD combines different methods to simulate the effects of light.

iTACITUS: Virtual Tours of the Past

Almost anyone visiting an archaeological museum would be happy to take a virtual trip back in time. Researchers at Fraunhofer IGD have already made that possible. For instance, visitors of the Allard Pierson Museum in Amsterdam were recently able to stroll through historical sites. Next to an abundance of artworks was a flatscreen monitor mounted on a rotatable column. Initially, it showed a section of a giant black-and-white photo depicting the ruins of the Roman forum that was hanging on the wall. But when a visitor turned the screen to the side, the monitor showed the left side of the photograph instead of the center. A camera was attached to the rear of the rotatable display. The monitor displayed information about what was being shown. A text explained that the camera was pointed at the ruins of the Temple of Saturn. At the same time a digital animation clip showed how the intact temple may have looked long ago. By turning the screen a bit more, the visitor was presented with information, images and videos on other ancient structures such as the Coliseum.

Fraunhofer IGD had taught the computer to recognize the image. The program therefore always knew which part of the image was in the center of the camera and could consequently fade in the matching overlay, which could be a text, a video or an animation. The original image was always clearly visible under the overlays that were faded in. Thus the visitor always knew where he or she was while taking the virtual stroll. Experts call this technology augmented reality.

Figure 4: Software that can bring archaeological treasures to life. By looking at real images enhanced with digital information, museum visitors can take a virtual tour of ancient buildings.

The software is still running in the museum on a minicomputer controlled through a touchscreen. This handy device offers a glimpse of a future trend towards mobile, virtual tour guides. For example, tourists will one day

be able to hold the device in front of a baroque castle and information will appear on the screen - customized to the user's preferences. Researchers at Fraunhofer IGD have been working on the iTACITUS project to see how something like this might look in practice. Portable computers have been programmed to function as electronic tour guides. This technology has already been used for the UNESCO World Cultural Heritage site of Reggia Venaria Reale in Italy and at Winchester Castle in England.

FOCUS K 3D: Multimedia 3D Content

Focus K 3D performs preliminary intelligence work on the topic of knowledge technologies for multimedia 3D content. Four taskforces were established as part of an EU Coordination Action from the areas of virtual product development, cultural heritage, medicine, bioinformatics, and games and simulations to ascertain what the state of the art is and strengthen the networking of existing projects. The taskforces also continue to compile new requirements from the industrial and scientific communities. By the end of the project, their findings will have been used to draw up roadmaps and identify areas that should receive more attention from R&D efforts in the future.

THESEUS Medico: A Search Engine for Medical Image Databases

THESEUS is a research program initiated by the federal ministry of economics and technology (BMWi) to simplify access to information, network data to new knowledge and create the groundwork for developing new services on the Internet. THESEUS Medico is a part of this research program. Its mission is to build an intelligent, scalable and robust search engine to be used in medical image databases. Algorithms have been developed to independently extract knowledge from existing medical image databases so that complex medical queries can be submitted. As a result, it is possible to obtain detailed information about the type, scope, location and proximity of noticeable changes in medical images.

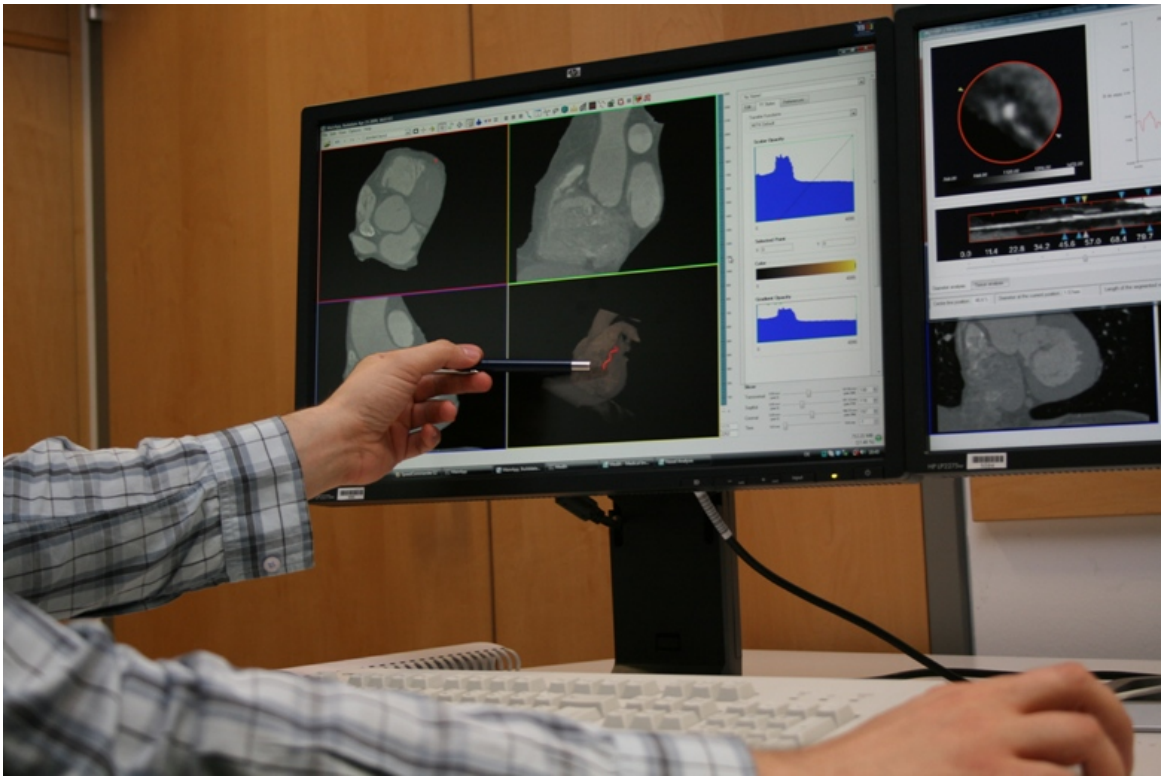

Figure 5: THESEUS Medico - searching medical image databases.

Digital Engineering: Integrating Virtual Mechatronics

A number of problems have to be solved at the computer before a new automobile, airplane or ship can be built. This process has been improved with the introduction of FunctionalDMU by four Fraunhofer institutes (Fraunhofer EAS, FOKUS, LBF and IGD).

With FunctionalDMU a computer is used to generate experimental models of a mechatronic system and simulate the interactions between mechanics, electronics and software. Mechatronic systems integrate and connect mechanical and electronic components with each other. FunctionalDMU enables developers to take account of the interactions between the various technical areas. Some industrial sectors are desperately searching for software tools and methods that they can use to integrate virtual mechatronic products at an early stage of their development processes. FunctionalDMU can meet this need.

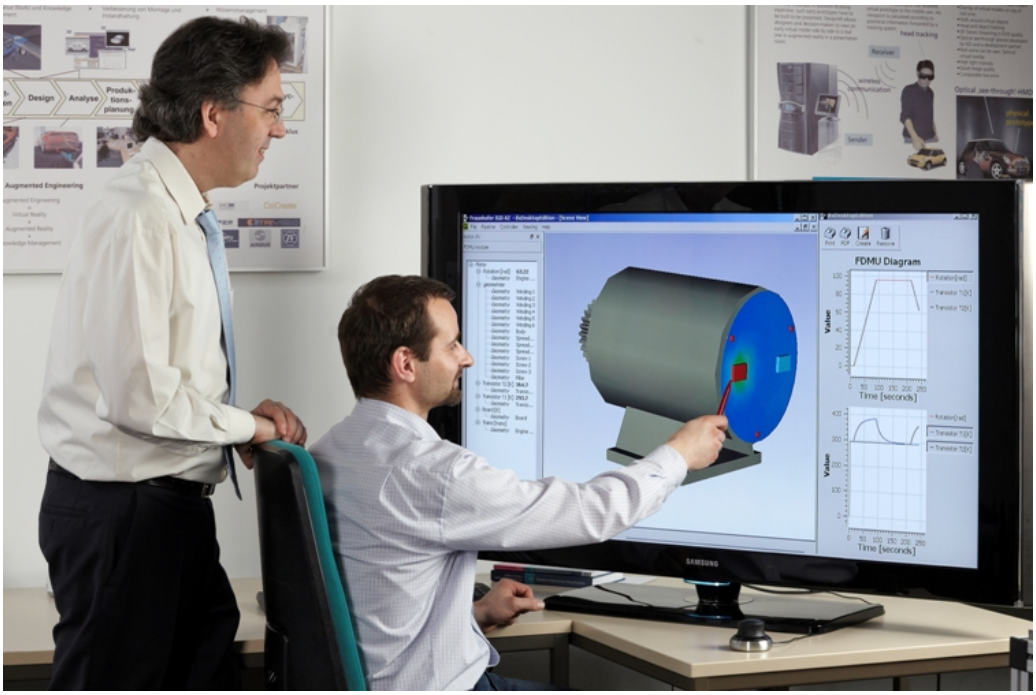

Figure 6: FunctionalDMU enables developers to take account of the interactions between the various technical areas.

When, for example, a finished automobile does not work in some respect, the cause frequently lies in the interplay of some of its components. To detect those of problems early, FunctionalDMU can be used to generate experimental models that simulate whether electronics, software and hardware (mechanics) work as planned under all conditions. FunctionalDMU utilizes information from the standard software being used by design engineers. The probability that the final automobile, airplane or ship will work as intended in all situations is greatly increased. The effort required for functional verification of a complex design is decreased.

The developments are currently focusing on the automobile industry, but the methodology can likely be transferred to other areas such as aircraft and ship construction.

Intelligent Environments: Simplifing Life for the Elderly

The aging society is confronting us with ever greater challenges. More and more people need intensive care for longer periods of time. Yet the elderly want to retain their independence at home for as long as possible. This is one of the reasons why researchers are working on intelligent environments, environments that recognize and respond to the wishes of the people in them.

If only my apartment could respond to simple movements of my hand, adapt to my mood and check my vital signs, life would probably be easier, more comfortable and more secure! It is precisely today's growing numbers of seniors who stand to benefit most from further progress in the area of intelligent environments in terms of

personal independence and a longer, dignified life in the surroundings familiar to them. Intelligent environments will soon be making life easier for us all. We will be able to turn the TV on and off with a simple motion of the hand. Portable sensors will recognize how we feel, register our movements, measure our fitness and let us know when we need more exercise or when we have had enough. We are concentrating on developing software that operates services in Ambient Assisted Living environments: everyday life in an intelligent apartment of tomorrow. A slide show is run by gestures, a glove recognizes its wearer's current mood, and a normal cell phone measures its user's physical activity.

Figure 7: Ambient Assisted Living environments: everyday life in an intelligent apartment of tomorrow. A slide show is run by gestures.