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**Global Illumination Simulation in Interactive Environments**

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Global illumination plays an important role in three-dimensional computer graphics, since it contributes significantly to the visual realism of a scene. Due to its view independence, the Radiosity method can be applied very well in interactive systems, e.g. in Virtual Reality (VR) applications.

However, so far the application of global illumination simulation has been limited to »Walk-Through« applications within static environments, in which viewing parameters could change, but the scene itself had to remain untouched. The reason for this are high computational costs of the simulation methods, which required a pre-processing of the simulation before the interactive Walk-Through (»off-line simulation«). On the other hand, there is an increasing demand for direct interaction within three-dimensional scenes including global illumination effects.

In order to enable interaction while maintaining visual realism in these scenes, the global illumination simulation has to be linked closer to the visualisation step – simulation will have to be performed »online«. In this thesis, a concept has been developed for connecting a Radiosity system to a VR system. In this concept, called »Online-Radiosity«, the simulation runs parallel to the VR system but as a separate process. Both processes communicate via messages, and the simulation results are handed over to the renderer of the VR system via shared memory. Thus,



**Dr. Frank Schöffel celebrates his graduation**

it was made possible to integrate a consistent global illumination including realistic soft shadows, calculated on a physically correct basis, into an interactive system which so far could provide no or only unrealistic lighting effects.

While the integration of a Radiosity system allows the adaptation of the lighting situation according to interactive modifications, it cannot supply real-time feedback to the user. However, a fast shadow feedback provides an important visual cue and can help in navigation and positioning tasks, and is therefore an important feature in VR applications.

The »Multipoint« method has been developed in this thesis, which provides a fast, approximate shadow by applying several simplifications and it thus enables a real time feedback in interactive environments. Calculation speed and shadow accuracy are adjustable by the user. Since this method operates on the same data structures as the Radiosity method, it can be integrated directly into the »Online-Radiosity« concept. The result is a hybrid system, which offers both a real-time shadow feedback based on the Multipoint method, and a more exact global illumination simulation based on

the Radiosity method in interactive environments.

Furthermore, it was examined how existing algorithms for efficient global illumination updates, based on the Radiosity method, can be further improved. One of the most powerful of these algorithms is the Linespace method, which is based on Hierarchical Radiosity and Clustering. However, this procedure requires enormous storage space, which prohibits its application to complex scenes. To overcome this drawback, a dynamic memory management was developed. This memory management keeps only data limited to the important regions of the scene i.e. in which interaction and modifications take place. Using a simple movement prediction, future object positions can be predicted, and the data for these regions is then calculated and timely provided just before the Radiosity process actually needs it. Unnecessary data, e.g. behind the moved object, is removed. Thus, only information which is actually needed is stored, which results in a significant reduction of memory needs and allows an application of the algorithm to more complex scenes.

With the methods developed in this thesis, a hybrid concept has been presented which integrates both a real-time shadow feedback and a physically based global illumination simulation into an interactive system. Due to the adjustable nature of the methods, the concept can be applied also to scenes of realistic complexity.

### Development of a Concept for the Compression of Stereographic Videostreams

*Diploma thesis by: André Greb  
Supervisor: Dipl.-Inform. Urs Krafzig*

The processing of image sequences typically requires a great number of operations for large data quantities. This particularly applies to stereographic image sequences, where the amount of raw data basically doubles. In order to keep storage space limitations or given bandwidths more efficiently, it is important to reduce the amount of data by applying suitable compression procedures. At the Department of »Communication & Cooperation« at the Fraunhofer IGD in Darmstadt, a system which provides close-to-reality spatial audiovisual impressions has been developed with regard to telepresence and telecooperation. Its visual component uses a stereographic camera system which – due to the inherent lack of transfer-efficiency for stereographic images – has served as a starting point for the creation of an appropriate compression concept. In order to avoid undue expenditure or »reinvention«, a concept based on established image processing methods such as the well-known MPEG and H.26x standards has been created. The main idea of this concept is based on the usage of embedded disparities in stereographic image pairs by employing a modified motion compensation. In addition to some general considerations about image compression techniques, it comprises a composition of several approaches and ideas.

### Design & Prototype Implementation of a Booking System for Paymentflow on the Basis of Electronic Contracts for a Distributed Java Application

*Diploma thesis by: Andreas Schöbel  
Supervisor: Mehrdad Jalali-Sohi*

In most cases, producer's rights are not protected when selling digital goods over the Internet. Therefore, applications are needed that are convenient to handle and fully integrated in transaction procedures while protecting the producers' rights and auto-

matically managing the money flow between vendor and client.

A potential solution of this problem is the »FILIGRANE« framework. »FILIGRANE« bases on a scenario of three actors trading with each other.

To observe resulting business contracts, there is the Rights Clearing House and the Fee Collecting Agency. The Rights Clearing House saves and checks all contracts and the Fee Collecting Agency collects and distributes fees of the concerned parties.

The aim of this diploma thesis was the development of a Fee Collecting Agency as a bookkeeping system based on the implemented parts of the hole framework. Here, all cash values are captured and automatically forwarded to the according parties as based on the contracts saved by Rights Clearing House.

The application supplies every user with an internal bookkeeping account. When a deal comes about, payment will be booked to the respective accounts by the application. The account balance represents the credit of the corresponding user. On request, the user can balance out his account and the money is transferred.

### Evaluation of Document Management Systems for a Research Institutes Needs by Prototype Implementation

*Diploma thesis by: Margit Olbrich  
Supervisor: Erik Meissner*

Within the international network INI GraphicsNet many projects have been implemented department or location-wide. Documents usually serve documentation purposes (project, practical course, diploma, etc.), advertisement purposes (flyer, video) or are created as scientific publications. As is the case of many cooperative documentation processes, a revised version is often created for stored documents and not necessarily by the originator. A DMS can handle the resulting problems for the document's administration. The DMS is a flexible solution which supports all administered documents and versions. This applies in particular to documents from the electronic data processing.

The target of this thesis was to form a decision basis for a document management system (DMS) by an evaluation process based on different DMS in order to supply the selection for a technical base of a suitable system for future remote document management. This system should then be an important solution component in a future

systematic knowledge management.

The work describes an evaluation of three marketed document management systems which were prototypically implemented in the environment of the research institute INI GraphicsNet. In the process of the work these were tested under the requirement criteria of the institute environment. The criteria were determined before implementation and submitted to a user test. The resulting efficiency study provided all needed data for a later implementation within the institute's environment.

### Development of an Authoring Tool to Interactively Design Dynamic VR-Applications

*Diploma thesis by: Oliver Hirschberg  
Supervisor: Dipl.-Inf. Johannes Behr*

Most virtual reality systems support application-dependent changes of the current scene by allowing developers to integrate a central animation component, which manipulates the geometry and transformation data between separate frames. In contrast to this traditional approach, modern VR-systems (like the Avalon system) put the task of behavior description directly into the nodes of the scene graph. Thus, the scene graph not only holds information about the static geometry data but also about the description of the dynamic behavior and interaction elements. The scene graph nodes offer a communication mechanism by providing slots for incoming and outgoing messages between nodes. Dynamic applications are developed by creating objects and connecting them with each other, thus specifying the relations between these objects. Currently available tools poorly support this approach. They usually allow to edit the basic geometry layout of an application, but offer no or little support for the dynamic aspects of a scene.

In this thesis, several freely and commercially available VR-Systems and VRML-tools are examined and classified concerning their capabilities to support a developer in creating new applications. The advantages and disadvantages of these tools are illustrated. Based on this survey, an authoring tool prototype was created that can display and edit applications developed for the Avalon system. The tool was integrated into the Avalon system and allows an interactive creation of new and the deletion of existing connections between nodes. The changes take effect immediately and supply

the developer with feedback while the application is still running.

Furthermore, it displays a representation of the current scene graph and gives detailed information about a selected scene node.

### **Interactive Augmentation and Illuminance Reconstruction of Photographs using Radiosity**

*Diploma thesis by: Thorsten Grosch  
Supervisor: Dipl.-Inform. Wolfram Kresse*

The Radiosity method enables an increase of realism of computer-generated scenes with a physical lighting simulation. In augmented reality applications, it is important to modify existing photographs by inserting virtual objects. The virtual objects should appear under the correct lighting conditions. In this thesis, a method for augmenting photographs based on a Radiosity simulation was developed. Additional objects are added to the scene and the result of the Radiosity simulation is displayed in the photograph using a differential rendering technique.

Usually, necessary parameters for a lighting simulation of the scene shown on the photograph do not exist. However, a Radiosity simulation requires the geometry of the scene and the camera parameters as well as light and material properties.

Therefore, methods for reconstructing these parameters from photographs were developed. With a pointing device, virtual objects can be moved interactively within the photograph and to display the result, the user can choose between a fast update with lower quality and a slow update with high quality. Other possibilities are adding new light sources and the modification of existing lights and materials. All algorithms were integrated in the Radiosity simulation system GENESIS 2.

### **Instruments of E-Loyalty for a Geodata-Portal**

*Diploma thesis by: Ina Schäfer  
Supervisor: Dr.-Ing. Uwe Jasnoch*

The majority of enterprises are aware of the significant factor of customer loyalty. However, the customers' own perspective is often ignored. Consequently, many companies are not able to create the optimal »loyalty-mix« and it comes to drawbacks in customers loyalty. Reason is often the imperative

of the product, often strengthened by an organization related on products and not on customer divisions.

The diploma thesis aims at an identification of the state of the art of instruments for electronic customer loyalty, called e-loyalty. One major result of the thesis is the identification of at least five e-loyalty-factors which are implemented by well-known companies and are presently dominating the market of customer retention: Vision and management strategy, e-branding, community building, individualization/interactivity and process design.

Each of these e-loyalty-factor is discussed in detail by a variety of case studies of reputable or innovative enterprises. For instance, the diploma thesis analyses the website of the Kraft-Jacobs-Suchhard brand Milka concerning design, tonality, added value and usability as a best practice solution. The computer manufacturer Dell is represented as a specialist in tailoring personal computers by mass customization as well as process design of its enterprise processes.

However, before a loyal customer behaviour is achieved, companies are recommended to concentrate on customers' perspective to meet their expectations in order to create real customer satisfaction which represents the basis for loyalty.

The final part of the paper tries to give a recommendation about instruments of e-loyalty for the geodata portal In Geo Information Center (InGeo IC) from the Fraunhofer spin-off GISec.

### **Evaluation and Implementation of Algorithms for Geometrical Reduction with Error Control**

*Diploma thesis by: Horst Birthelmer  
Supervisors: Dipl.-Inform. (FH) Ingo Soetebier, Dipl.-Inform. Jörg Sahn*

Producing increasingly complex geometrical data turns the task of data reduction into a pressing issue. This diploma thesis compares common techniques from the field of simplification. The algorithms should simplify arbitrary meshes and reverse simplification by re-inserting the removed information. The process is controlled by an error tolerance value provided by the user. This ensures that the distance between the simplified and the original mesh will not exceed this tolerance value. The simplification can also be controlled by the number of remaining triangles in the simplified

mesh. An evaluation showed that none of the algorithms was able to meet all requirements. Therefore, a new algorithm was needed. The second part of the diploma thesis deals with this new algorithm and its implementation. It is able to simplify arbitrary meshes which means that there are little assumptions to be made about the input mesh. The data which has been removed from the mesh is stored in a progressive structure so that the entire original mesh can be restored on request. The error tolerance will not exceed the given value during this process. The problem can be solved by reducing a great amount of triangles so that the distance between the reduced and the original mesh is definitely smaller than the tolerance value, the quality of the resulting mesh remains similar and the simplification can be reversed.

This algorithm fulfils the requirements by performing the error calculation as local as possible, being able to deal with errors in the mesh and performing just as much calculation as needed.