



**Dr. Wolfgang Müller-Wittig
Integration of Haptic Displays and
Behaviour of Anatomical Structures
providing innovative interaction
techniques**

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This work was influenced by two paradigm shifts: in medicine there was a transition from open surgery to minimally invasive surgery – surgical interventions are done through small incisions in the body in which a miniature camera and surgical tools are manoeuvred – these complicated techniques require a specific training; and in computer graphics 2-D interaction was replaced by 3-D interaction using Virtual Reality techniques.

The goal of this work was to develop a concept and methods for a VR based medical simulation providing a highly realistic surgical environment including anatomical structures and surgical instruments. Especially, a »natural« interaction should be guaranteed considering the various human senses.

For that reason the concept introduced in this work focused on the model (virtual anatomy) and the manipulations (surgical interventions). Moreover, main development tasks were the specification of interaction devices and the simulation of the visual and haptic feedback.

A reconstruction pipeline was introduced which allows the generation of realistic anatomical structures based on patient specific image data sets. This virtual anatomy is suitable for realtime simulations, while preserving useful details (individual characteristics and pathological findings).

Hence, a variety of surgical instruments (e.g., virtual endo-



Dr. Wolfgang Müller-Wittig celebrates his graduation

scope, probe, forceps) were integrated into the VR based medical simulation system. Both shape and function of these virtual tools were preserved. Consequently, new interaction devices can be specified and simulated allowing the use of the origin instruments.

Moreover, as main surgical interventions deformation and cutting were simulated. To achieve this goal two methods were developed for the deformation processes – a local geometric oriented approach and physically based one. The simulation of the cutting procedures were realised via abstraction of the cutting tool and use of templates providing a realistic visual feedback.

In addition, the haptic feedback was realised by introduction of a method for haptic rendering and integration of a haptic display. Especially the required high update rates for a realistic feedback were provided considering the haptic characteristics of the virtual structures.

Finally, a graphical user interface was developed consisting of a display area and a menu area to specify parameters (e.g., angle of optics) and to show some status information (e.g., collision statistics). By this way standard training situations can be realised allowing an objective assessment.

The applicability of the concepts introduced in this work were proved in the development of several medical training systems (e.g., knee arthroscopy, rhinoscopy, hysteroscopy). First evaluation results showed that such surgical simulators are appropriate for practising surgical techniques without having to advance the learning curve on humans. Considering that several decades were necessary to develop high sophisticated flight simulators, which are available today, rapid developments in recent years and the promising results presented herein give hope that VR based training simulators will be integrated into the medical curriculum in the near future. In addition, concepts and methods developed herein can also be used for preoperative planning and intraoperative support. In conclusion, these simulation techniques and innovative technologies will increasingly emerge into the operating room, towards the real patient resulting in better surgical outcomes.

Application of XML for the optimization of business processes

Diploma thesis by:

Dr. Angelika Beyer-Neumann

Supervisor: Dipl.-Inform. Erik Meißner,

Dipl.-Inform. Luc Neumann

The goal of this work was to demonstrate that document-based business processes can be optimized by the application of XML (Extensible Markup Language). For this purpose a XML-based system was built up and the requirements for an optimization of a selected business process were established.

The work was carried out in the Multimedia Support Center Hessen (MMSC), which has among other things the task to carry through pilot projects with small and medium sized enterprises in order to develop new multimedia applications. Starting from the selected business process »Pilotprojekt« a document analysis was made for the document type »Projektantrag«. A project proposal is the main document of the business process »Pilotprojekt« and simultaneously the fundamental base for the promotion of a pilot project by the Ministry of Economics, Transportation, Urban and Regional Development in the state of Hesse (HMWVL).

During the analysis of several project proposals potential semantic components of the documents were identified and classified afterwards. The following valuation of these components led to a number of elements and attributes, which built the base for the modelling of a DTD (Document Type Definition) for project proposals. This DTD represented again the basis for the creation of DTD conformable XML document instances.

With the desktop publishing system FrameMaker+SGML at first structured documents of the type »Projektantrag« were created in a proprietary format, which were converted afterwards into XML. In order to output the structured FrameMaker+SGML documents in a proper way on paper layout definitions were made. In a stylesheet with XSL (Extensible Stylesheet Language) was specified how the XML documents should be presented in the World Wide Web.

For storage the XML documents were imported into the XML database eXcelon 1.1. With retrieval inquiries, based on the XML Query Language (XQL), it was possible to address individual components of the project proposals.

With the structure of the XML based system it could be shown, that XML possesses the potential to optimize document-based business processes. The optimization of the selected process was achieved e.g. by an improvement of the quality of the project proposals, faster access to and the more efficient use of the contents of the project proposals.

Mapping Polyhedral Models to 2D

Diploma thesis by: Gunther Olesch

Supervisors: Dipl.-Inform. Marc Alexa

For many applications, it is useful to have a parametrization of a polyhedron's surface with only two coordinates. These parametrizations can be found but it is not easy to obtain a »good« parametrization for a given application. Parametrizations of closed surfaces always involve discontinuities because the object must be converted into a topological disk by making some kind of an incision into the surface. Applications typically produce unsatisfactory results in these places, and every parametrization can therefore only be used for small regions of the surface.

In this thesis, the following approach to solving this problem is investigated: Several parametrizations are created, each one to provide »good« results in a different region of the polyhedral model. The application is then run with each one of these parametrizations, and weighted mean values are calculated for the final results. For this purpose, points are marked on the surface, and a boundary is induced around each of these points. The part of the model which is inside a boundary is mapped to a topological disk.

For creating these boundaries, I supplied an algorithm, which still leaves some options up to the user's discretion. No fixed laws, generally valid for all applications and models can be found for choosing these options. I depended on a few rules of thumb, based on my experiences.

In order to change the actual mapping to 2D, I made use of techniques that are already available.

I implemented two applications and investigated their usefulness: texturing and 3D morphing.

The application for interpolating or approximating texture coordinates usually returns useful results. However, once and again, some undesirable effects can be observed which cannot be predicted and only become apparent after having performed the time consuming calculations. Calculating multiple mappings and averaging the texture coordinates prevents the most ugly effects, but will by no means result in better texture coordinates than each single mapping.

In the application for 3D morphing, the mappings to 2D are used to map the vertices of the first model to coordinates on the surface of the second model. This procedure results in an approximation of the second model with the topology of the first model. To determine their correspondence, the user only marks a few vertices on both models. This technique is independent from the genus of the models. Unfortunately, I came across numerous fundamental problems resulting from the usage of two dimensional mappings. Often extremely unsatisfactory results were produced, some of which are even worsened by averaging the coordinates.

All techniques described in this thesis were implemented in Java.

Computerbased visualization of an optical lens system

Diploma thesis by: Carsten Wächter

Supervisor: Dr.-Ing. Volker Luckas

In many industrial fields Head-Up-Displays (HUDs) have been introduced during the last few years. Head-Up

Display systems have been used in airplanes for many years to show important information directly in front of the pilot's head. In order to reduce the development effort of such systems, it would be very useful to have a software system which is able to simulate and test the capabilities of the system.

The general aim of this diploma thesis was to develop a simulation software for optical systems. An optical system can consist of certain well positioned optic elements like lenses or mirrors. A description of the optic elements should be found which allowed to choose the parameters like index of refraction, radius etc. without limitations.

The object which is projected by the optical system was considered as a two-dimensional object which consists of discrete image points (pixels), for example an LCD-Display. The image of the object was projected on a flat

screen. For the optic elements as well as for the display and the screen the relevant parameters for the projection were evaluated within that thesis.

Three different solutions were discussed:

- a) Ray-tracing through the optical system by using a specific raytracing software.
- b) Computing the projection without ray-tracing by using the parameters of the optical system calculated by the software.
- c) Connecting a conventional ray-tracing software to the simulation system automatically generating a script for the raytracing software.

After a general discussion of the advantages and disadvantages the last solution c) was chosen for implementation of the prototype. During the specification of the underlying concept the basic requirements for the software system and the methods for the implementation were discussed. Especially the representation of the optic elements, the way the rendered images are created and the user interface are described in detail. Additionally the implementation of the software prototype together with the used software tools like POVray, flex and bison is discussed.

Interactive Segmentation and Post-processing in a 3D-Viewer on the basis of Registered Range Images

Diploma thesis by: Sven Schulmeyer
Supervisor: Dipl.-Math. Sven Gürke

For dental restauration of damaged teeth, especially ceramic inlays have proved apart from gold inlays. Ceramic inlays dispose of a number of obvious advantages, but their production in dental laboratories is still work- and cost-intensive and it requires a lot of good technical skills and manual work from both dental technicians and dentists.

For the processes of making molds, producing and inserting the inlays up to final adjustments, a number of sessions at the dentist's are necessary for the patient. In consideration of these facts, a computer-based reconstruction of damaged chewing surfaces to assure an efficient supply for the broad public has become more and more important.

Today's available industrial computer systems already allow an automation of this production process. Restaurative parts are produced out of a baked blank ceramic whose substance is quite similar to that of natural teeth,

and which meet the present cosmetic requirements.

The task of this thesis has been to develop an interactive segmentation and postprocessing technique on basis of registered range images and to integrate them into an existing dental CAD-system for automated tooth reconstruction. An edge will be automatically extracted on basis of marked points. In the ideal case, a single point to be marked will be sufficient. To give a practical example, the segmentation technique has been applied to the equatorial line and the cavity border of tooth scans. The interactive marking of points and the visualization of the results have been integrated into a 3D-viewer.

Due to deficient original data or technical difficulties, the segmentation technique might deliver distorted results. For this reason, it is necessary to postprocess and to correct the output. Intuitive tools have been provided for the necessary user interaction. Through the postprocessing technique a 100%-correctness of the produced output, which is required for medical applications, can be achieved.

Methods for Recognizing Manipulations on Graphical Authorization Tickets

Diploma thesis by: Henning Daum
Supervisors: Dr. Christoph Busch

In the age of e-commerce it is common to buy goods over the internet. But for tickets and other value documents, this does not apply. The first approach is via the Internet but the transaction is done by mail. The reason for this is clear: The ticket as an authorization for an attendance could be forged or copied. Tickets in online ticketing contain an additional, unique, machine readable token, which includes security mechanisms like digital signatures.

In the diploma thesis »Methods for recognizing manipulations on graphical authorization tickets«, various methods for detecting changes on the human readable part of the ticket were developed. Several approaches have been integrated in the existing online ticketing system »Online-Ticket«.

Firstly, an analysis of available online ticketing systems and their functionality was carried out. Then, the time of the possible use was determined: A check could be done always and for all tickets or just in case of a suspicious ticket. Different prerequisites apply respectively.

For the approach of controlling all tickets, the technology of optical char-

acter recognition (OCR) was evaluated. A corresponding demonstrator was developed and OCR was integrated into the control station of Online-Ticket.

In case of single checks for suspicious tickets, the main focus was to be independent of computers. After the treatment of some simple security mechanisms, a systematic analysis of the technology of visual cryptography for detection of manipulations was realized. Subsequently, a demonstrator was developed a lead to the final implementation in Online-Ticket.

In addition, a method to detect hidden information was integrated which is based on the position of card elements.

Efficient Real-Time Level-of-Detail Rendering Using Surfels

Diploma thesis by: Patrick Reuter
Supervisors: Johannes Behr, Christophe Schlick (LABRI Bordeaux, Frankreich)

A novel point rendering algorithm is presented using surfels as rendering primitives. A surfel is a discrete 3D surface element consisting of the attributes position, normal, and color. It is shown, that a 3D object representation by surfels can be created directly from point clouds of 3D scanners, from polygonal meshes, and from implicit surfaces. The surfels are compressed using quantization schemes for each of the three attributes, and stored in a full binary space partitioning tree in order to render the 3D object in various level-of-details which are view-dependently defined. Three rendering speed-up techniques are presented: hierarchical view frustum culling, hierarchical backface culling using normal masks, and the exploitation of view coherence.

Nameservices for Mobile Agent Systems

Diploma thesis by: Jan Peters
Supervisor: Dipl.-Inform. Volker Roth

In recent years, rapid development can be observed in the areas of the world wide web which enables the global supply of customized services, the mobile telecommunication with its terminals getting more and more intelligent and the distributed computing used to solve tasks on distributed resources. In the context of these three currents, which go into one another in computer science (and

industry), a mobile agent represents an almost perfectly adapted concept, which helps its owner to fulfill tasks making use of the possibilities given by these three areas.

Mobile agents are programs which are dispatched to remote computers within a network, where they execute their tasks autonomously in interaction with agents and services. An infrastructure of agent servers becomes necessary to administrate these agents and transport them from one computer to another. In order to coordinate mobile agents in multi agent applications and to enable the exchange of messages between such agents independent of their position, a name service is needed which pursues the change of the agent's positions.

So far, no concept for such a service was existent which met the special requirements for mobile agent systems. Apart from the high alteration rates which must be considered, the ability of scale within large confederations of agent systems is a major request.

In the diploma thesis a location service for mobile agents is developed, which enables the owner of an agent to locate its current position at any time, while it is migrating through the network and executed on remote computers. Designing the service, particular value has been put on the analysis and fulfilment of the requests mentioned, in comparison with existing name services and mobile agent systems. It was important to present a secure service, in which attacks by aggressors are detected and prevented and network errors are taken into account and treated accordingly, as far as possible

In the first section an overview of the following topics of computer science touched by this work was given: agent technology, name and directory services, scale in distributed systems. It was tried to discuss these topics so far that a founded theoretical basis for the comprehension of development decisions was present.

The second section outlines the development of the service, that registers the positions of mobile agents in an efficient manner using an infrastructure of clients, proxys and servers and enables users to lookup these positions afterwards. The function of the individual components and their interaction with each other are described. Apart from the specification of the interfaces, the design of a special protocol for secure communication between clients and servers within the network was developed.

Moreover a component for dynamic configuration and administration of the server's infrastructure was presented. Concluding, the analysis of concrete attack scenarios and the discussion of possible error sources are given.

By the implementation of a working model and its integration into the mobile agent platform SeMoA (Secure Mobile Agents) the efficiency of the model could be shown and the adjustment of the generic model to a concrete working environment could be described with this prototype, at the same time.

Conceptualization and Implementation of a Context-Management-Component for User-Assistance of Electronic Devices

*Diploma thesis by: Holger Bach
Supervisors: Dipl.-Inf. Jürgen Schirmer
Dipl.-Inf. Luc Neumann*

Today's electronic world requires the end-user to have more electronic assistance. An electronic assistance system can anticipate the current needs of the end-user and provide an instant and efficient information and service delivery.

The situation of the user is defined by his goals, habits and preferences and the electronic resources like devices and consumable services.

For example, in the event a specific user arrives with whom the end-user wishes to speak, a reminder mechanism can be initiated. The current location of the user, the noise-level and the temperature define his current environment.

These things define the current context, which is tracked by sensor agents.

The context manager, which was realized within this diploma thesis, has to take care of all these informations. To simplify the usage of the context information from heterogeneous systems and components, KQML as an agent communication language was proposed as the interface protocol for the context manager.

Each component added to such a situation-aware enriched system has to register and advertise its service to the context manager. The context manager provides a routing service and a service brokering facility. The contextmanager can be regarded as a global persistent knowledge base, storing informations used by more than one component. It is usable from heterogeneous systems and programming languages. It delivers a sys-

tem-wide homogeneous view to the data through an efficient access mechanism.

The data management part of the context manager is based upon the resource information base (RIB) used in the AdaWeb-System.

All data in the RIB is organized in individually ordered layers. This concept was extended by the use of time flags to guarantee consistency and enable a history mechanism. It is not possible to remove information from the database. Information is deleted explicitly by overwriting with new information or removed automatically at an end time specified by the producer agent. This mechanism also reduces message traffic and management effort.

There are two services to access informations: polling and notification. Polling means that an agent asks for the information and gets one answer to that question. With the notification mechanism, a component registers for an event and receives an answer everytime that event occurs until it unregisters. Without such a service the agents have to query for information, even if there were no changes. The event mechanism reduces traffic and processing time.

First test drives have shown the usefulness of the mechanism and interface.

Within the diploma thesis a sensor agent and assistant agent, both using the context manager component, were developed. The sensor agent wraps the active badge system currently being in usage within the ZGDV department Z3 and provides location and movement information to the context. The assistant agent is a simple IN/OUT Board visualizing the current location and movement of users.

Such situation-awareness of systems provided by the context manager and sensor agents allows for an instant and sophisticated information processing, helping the end-user to best perform his daily work.