Institute of Visual Computing

Bonn-Rhine-Sieg University of Applied Sciences, Germany

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***Abstract*—This paper presents the soon to be founded Institute of Visual Computing at the Bonn-Rhine-Sieg University of Applied Sciences in Sankt Augustin, Germany. The research focuses as well as an overview of current projects are going to be part of this presentation.**

Keywords: VR; AR; mixed reality; interactive computer graphics; computer vision

I. INTRODUCTION

The Bonn-Rhine-Sieg University of Applied Sciences was founded in 1995. It is a young university with more than 6000 students, approximately 131 professors and 156 researchers. They are supported by more than 230 highly qualified lecturers from the fields of academia, business and industry. An additional 137 employees are working for the Administration, the Library and the Language Centre. The University campus is located in the neighbor cities Hennef, Rheinbach and Sankt Augustin (HQ), Germany. In Bonn, the University of Applied Sciences runs the B-IT Universities Institute of the Bonn-Aachen International Center for Information Technology jointly with Bonn University and Aachen Technical University (RWTH).

Beginning of 2011, the president of the Bonn-Rhine-Sieg University of Applied Sciences announced the founding of the new institute of visual computing. Two years prior to this a group of university professors had applied with their current projects for such a foundation since it provided them with the possibility to accelerating their research work related to visual computing and looking for more and better synergies.

Currently 6 professors and more than 40 research associates and assistants are part of the institute. These numbers are constantly growing since the research projects which applied for future funding are going to require more people soon.

II. FOCUS

The field of 'Visual Computing' covers computer environment with a visual paradigm and technologies that enable interaction and control through manipulation of visual images.

The Institute of Visual Computing is carrying out research with respect to virtual, augmented and mixed reality, computer graphics and computer vision. The technologies currently being developed in the institute are going to bring completely new perspectives in terms of analysis, creativity, interaction, decision-making or manufacturing in all industrial, research, education and training sectors.

III. PROJECTS

In this section we are going to present selected research projects. They are good representatives for showing the quality of research being carried out at our new institute of visual computing.

A. Pixelstrom

Pixelstrom (in engl. Pixel stream) stands for FGPA-based image combining for parallel graphics systems.

The pixelstrom system is designed to visualize large 3D models/scenes and highly complex shaders in real time. In comparison to traditional parallel graphics systems the realized FPGA-based system reduces network traffic, latency and memory accesses by directly grabbing the rendered sub-images from the DVI-Ports of the render servers [1,2].

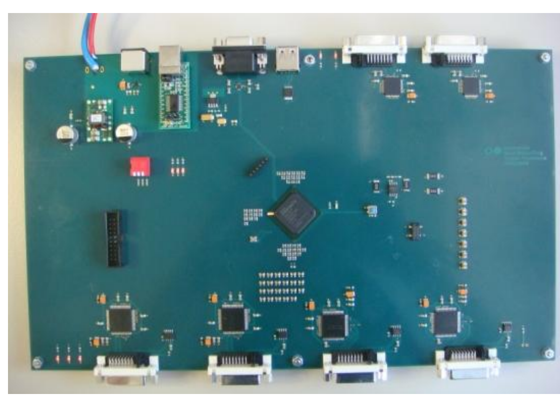

Figure 1. FPGA based combiner board

An especially designed hardware combiner merges the rendered sub-images. The goal of the work is to reduce network traffic and latency for increasing performance in parallel visualization systems. Initial data distribution is based on a common ethernet network whereas image combining and returning differs to traditional parallel rendering methods. Calculated sub-images are grabbed directly from the DVI-Ports for fast image compositing by a FPGA-based combiner.

B. *GrIP (Graph based post processing of visual data for interactive graphics)*

The GrIP project is working on a graph-based framework for post processing filters, providing the possibility of arranging and connecting compatible filters in a directed, acyclic graph for real time image manipulation. This means that the construction of whole filter graphs is possible through an external interface, avoiding the necessity of a recompilation cycle after changes in post processing. Filter graphs are implemented as XML files containing a collection of filter nodes with their parameters as well as linkage (dependency) information. Implemented methods include (but are not restricted to) depth of field, depth darkening and an implementation of screen space shadows, all applicable in real-time, with manipulable parameterizations [3].

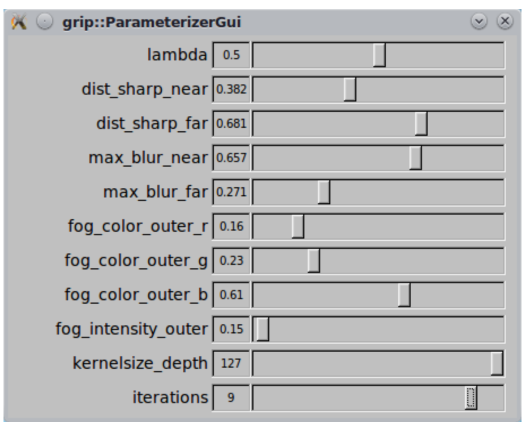

Figure 2. GrIP: Parameters for depth darkening, depth of field and fog in a single parameterizer GUI

Figure 3. GrIP: Rendering of Sponza with depth darkening, depth of field and fog using the values from the GUI screenshot above

C. *TraCell (Streamed Ray Tracing of Single Rays on the Cell Processor)*

In this project an approach is elaborated to efficiently trace single rays on the Cell Processor, instead of using ray packets. To benefit from the performance of this processor, a data structure is chosen which allows traversal without excessive accesses to main memory. Together with careful optimization for SIMD processing, a performance comparable to a packet based ray tracer, running on the same hardware, is achieved. In special cases, when the coherency of the traced rays gets very low, it even outperforms the packet based approach.
The system consists of a modular Virtual Reality framework and a cluster-based ray tracing rendering extension running on a number of Cell Broadband Engine-based servers. The VR framework allows for loading rendering plug-ins at runtime. By using this combination it is possible to simulate effects interactively from geometric optics, like correct reflections and refractions.

Figure 4. TraCell: interactive global illumination of a car model

D. *VOLT (Interactive Volume Rendering with CUDA)*

Real-time high quality direct volume rendering is a computational intense task. Clusters for parallel rendering, specialized volume rendering hardware or the reconstruction of iso-surfaces were the main approaches in the past to reach interactive frame rates. Emerged GPGPU techniques such as slicing are not able to deliver the same quality. The CUDA architecture being developed in this project enables fine grained access to massively parallel graphics hardware. Volt is an interactive direct volume renderer that takes advantage of these devices' properties for high quality interactive ray casting.

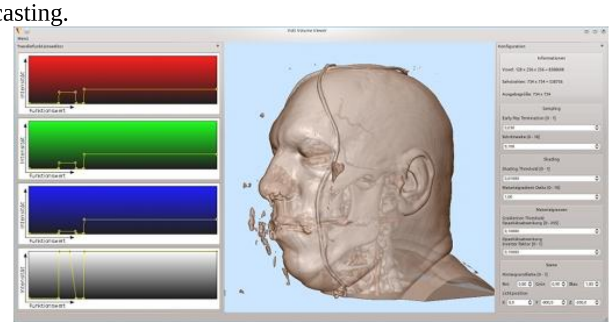

Figure 5. VOLT: application window and the VisMale dataset

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E. EXAR (School Experiments with Augmented Reality)

The EXAR project enhances school experiments by using Augmented Reality techniques. For the purpose of the EXAR project choose magnetic field visualization as an example were chosen. Students can hold magnets in their hands while wearing an HMD. Thus they are enabled to seeing the stereoscopic 3D magnetic field as an overlay to their view (see figure).

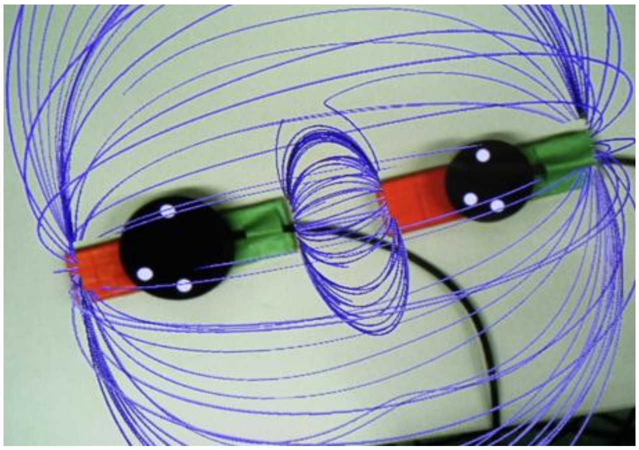

Figure 6. EXAR: Overlay view

F. IMBA (Image Based Tracking)

In Mixed Reality (MR) Environments, the user's view is augmented with virtual, artificial objects. To visualize virtual objects, the position and orientation of the user's view or the camera is needed. Tracking of the user's viewpoint is an essential topic in MR applications, especially for interaction and navigation. In present systems, the initialization is often very complex. For this reason, the IMBA project works on a new method for fast initialization of markerless object tracking. The method is based on Speed Up Robust Features and paradoxically on a traditional marker-based library. Most markerless tracking algorithms can be divided into two parts: an offline and an online stage. The focus of this project is the optimization of the offline stage, which is often time-consuming. The major impact on performance is caused by feature extraction and matching of their descriptors. Therefore, two implementations were evaluated. On a single dual core CPU (Intel Core2Duo T7200), the tracker achieves 4-5 fps depending on the number of extracted features. In the second implementation, a GPU-based library for feature detection has been used. This configuration improves performance up to 14-16 fps (nVidia GeForce 8800 GTX). Concerning accuracy and radius of movement, the tracker equals the common marker based tracking libraries, except some jitter and infrequent fails of position estimation. The introduced system is derived from a marker-based system, but in the online stage no marker is visible or needed. The next step would be to not only track a selected object, but measure/track also unknown environments like other Structure-from-Motion methods do.

G. Augmented Perception for diagnosis and orientation support

Augmented Perception aims at enhancing human perception in an intuitive way by adding information from technical sensors, with the intention to get as close as possible to an artificial sensory organ with its own perception channel. Such augmented perception can be of particular benefit in unusual environments where biological perception reaches its limits.

As it is impossible to produce new sensory channels in the human brain, augmented perception requires redundancy in sensory perception to transport the additional information without replacing (possibly relevant) information from the original sensory organ that uses this channel. In human sensory channels, redundancy exists only where it is a benefit in itself, e.g. in stereoscopic vision. Nature has taken advantage of this circumstance with the magnetic sense of some migratory birds, which gives a color to magnetic fields in one eye that differs from the color of the same part of the visual field in the other eye [4,5]. A similar approach can be followed for additional artificial senses for human orientation.
An application has been suggested for medical diagnosis. Many diabetes patients suffer from a peripheral arterial occlusive disease in the lower limbs, known as the "diabetic foot syndrome". Undersupply in nerves and muscles may result in necroses and, ultimately, the loss of a limb. Examination of the lower limbs combining visual and thermo graphic parts of the electromagnetic spectrum might help to identify regions of reduced blood flow early enough to take adequate precautions against irreparable tissue damage.

H. Fivis (Bicylce Driving Simulation in a VE)

The objective of this project is to design a real bicycle simulator that virtually presents traffic situations within an immersive environment. For this purpose the bike is mounted onto a motion platform with six degrees of freedom (6 DoF) that can provide a semi-realistic simulation of riding turns, of different track surfaces and additional external forces acting on the bike. Required data for the simulation is achieved by test drives with a bike, equipped with a variety of sensors. In addition, different basic visual stimuli can be specifically applied in such a visual simulation setting, offering the possibility to examine the impact of visual perception on physical and mental performance under controlled basic conditions [6]. Within the scope of this research project the correlation between the visually perceived motion and the physically generated motion will be studied for the first time. Furthermore, a ergonomic model is created for the investigation of attention and concentration during labor. The simulation surrounding enables the stimulation of cognitive performance, as it is found in real work situations.

Figure 7. Fivis: Bicycle simulator

IV. CONCLUSIONS

Several international co-operations are already established with a focus on different levels such as: master student and Ph.D. programs, bilateral exchange of researchers, EU cooperation projects, and industry research projects. Until today academic co-operation partners are: Brunel University – UK, University of New Brunswick – Canada, and the York University – Canada. The plan for 2012+ is to extend the cooperation network of the Bonn-Rhein-Sieg University by more partner universities and research labs worldwide.

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