Realtime Animation and Visualisation of Complex Scenes on Standard PCs (Abstract)

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Today, interactive computer graphics has to deal with data sets of increasing complexity. This trend can be observed in many application areas: In scientific visualisation, the complexity of data sets has grown enormously due to improvements in sensor and simulation technology. In the area of computer aided design (CAD), three-dimensional virtual prototypes of complex projects should be visualized and edited interactively. The entertainment industry has to deal with complexity problems, too: Recent computer generated feature films like *Final Fantasy* already come close to photo-realistic simulations of reality, thus requiring highly detailed three-dimensional models. Special effects for feature films (for instance the large crowd animations in the recent Lord of the Rings trilogy) also depict highly complex scenes. Interactive entertainment applications, such as computer games, aim at a photo-realistic simulation of virtual worlds. Such interactive applications pose especially high demands on graphic algorithms: As the user is free to move interactively in a virtual world, a large amount of detail has to be modeled. Different scales, ranging from leaves of grass to complete mountains must be included to sustain a realistic impression of different view positions. This leads to scene data bases of huge complexity. Additionally, all computations must be handled in real-time. All these developments lead to the somehow paradox fact that handling of complexity is today still one of the major problems in computer graphics, despite of the enormous advances in graphics hardware and algorithms.

In this talk, we propose a new approach to render highly complex scenes: point based multi-resolution rendering. The main idea of this technique is to reconstruct images from surface sample points: Instead of processing all primitives that describe a potentially high complex three-dimensional scene, we only pick a small set of sample points from the surfaces. Sampling is done using a sampling distribution that facilitates the reconstruction of an image later on. Such a generation of the sample sets can be done efficiently, in time mostly independent of the scene complexity. Hence, it is possible to apply the rendering algorithm to scenes of very high complexity while maintaining acceptably low rendering costs. The paradigm of reconstruction from point sample sets is a very general technique that can be applied to a large class of scenes, being more general than many former approaches.

We start with a discussion of the background from literature on related work in the area of rendering complex scenes and point-based computer graphics. Then we look at different data structures employed for sampling. Two different data structures will be discussed in detail: the first is a *dynamic sampling* data structure that creates sample points on-the-fly by randomized sampling. This data structure is the basis of the randomized z-buffer algorithm [1]. The second variant is a *static sampling* data structure, which uses precomputed sample sets. This data structure combines ideas of the randomized z-buffer technique and “Surfels” and “QSplat” [2, 3]. It can be easily extended to support animated scenes [4].

The dynamic data structure consists of a spatial hierarchy (an octree) of the scene. Each hierarchy node points to a piece of a nested *distribution* list (a list with summed area values of the primitives). The data structure is used to find groups of objects with similar spatial location. Then random sample points are chosen that are uniformly distributed on the area of the objects, according to the sampling density necessary at the spatial location of each group. Additional classification by similar orientation and similar area allows taking into account the orientation of surface fragments towards the viewer and to identify primitives (here: triangles) that receive many sample points. Such primitives can be excluded from point sampling and treated differently, typically by a more efficient standard rasterization algorithm. The data structure can be constructed in $O(n \log n)$ time for n triangles, using $O(n)$ space. Dynamic modifications (adding/removing primitives) can be performed in $O(h)$ time, with h being the height of the octree.

The static sampling data structure also employs an octree; it contains precomputed sample sets in its nodes. Large triangles are detected during preprocessing and stored at different hierarchy levels to be recognized during traversal. For the creation of sample sets, different methods are proposed. In addition to simple random sampling, different stratification algorithms can be employed that create sample sets of varying uniformity, leading to a different oversampling and thus to different rendering costs. A worst case analysis gives upper bounds for oversampling. The average case is examined empirically. We can also derive confidence bounds, showing that the randomized sampling algorithms produce valid sample sets with high probability at low costs. Overall, static sampling data structures can be constructed in $O(hn)$ time. Using a *nested sampling storage,* $O(n)$ memory demands can be ensured. A *full sampling* approach (similar to the “Surfels” data structure) , might yield superlinear memory demands, but in practice, the difference is usually not significant. The advantage of the latter organizations is that one sample point will only be used at one resolution level, hence allowing for employing a prefiltering approach to point attributes in order to fight noise and antialiasing artifacts [2].

The talk will demonstrate the power of point based multiresolution rendering with examples like large scene rendering, animation of complex scenes and sound rendering.

REFERENCES

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[3] Rusinkiewicz and Levoy: *Qsplat, in Siggraph 2000 Proceedings.*

[4] Wand and Straßer: *Multi-resolution rendering of complex animated scenes, Eurographics Proceedings 2002.*

Detailed information available on Michael Wand's homepage at www.gris.uni-tuebingen.de.

About the author
Prof. Dr.-Ing. Wolfgang Straßer

Wolfgang Straßer studied Electrical Engineering and Communications, and Computer Science at the Technical University of Berlin, where he received his Dipl.-Ing. (Masters in Engineering) degree in 1968. For three years following, he worked as a computer engineer for Nixdorf Computers. In 1971 he returned to TU Berlin as research assistant in Computer Science. In 1974 he earned the Ph.D. with his thesis work in the area of computer graphics hardware.

At present, Straßer is full Professor of Computer Science and adjunct Professor of Mathematics at Tuebingen. The graphics group in Tübingen employs about 20 researchers working in the area of Graphics Systems Design, Graphics Hardware, Visualization, Rendering and Geometric Modeling. The Lab is supported by grants from the German Science foundation, ESPRIT and industry. In 1986, Straßer started the successful series of EG graphics hardware workshops.

In the same year he was appointed director of the Department for Information Processing of the Heinrich-Hertz-Institut Berlin. There he worked in cooperation with Grundig, Siemens, and Nixdorf on advanced end-user terminals for future telecommunication services such as interactive cable-TV and viewdata. In 1978 he was appointed Professor of Computer Science at the Technical University Darmstadt. In 1986 he moved to University of Tübingen and founded the graphics research group.

He has published numerous papers in scientific journals and conferences and is the coauthor with Encarnacao of the standard graphics book used in Germany. He has given tutorials at EG conferences, was an invited keynote speaker, has chaired many conferences and workshops, and is a fellow of the EG Association. He is on the editorial boards of the Computer Graphics Forum, Computers and Graphics, and CAGD. Straßer is a consultant to the government and industry.