Abstract

The goal of photorealistic image synthesis is to generate pictures with a maximum degree of realism. For an observer it should be difficult to distinguish between a computer generated picture and a photograph of the same environment. One of the most important tasks in computer graphics is the visualization of the correct lighting conditions in a given environment. This can be achieved by simulating the underlying physical phenomena of light emission, propagation, and reflection. The most advanced algorithms for such simulations of radiative light transfer are radiosity methods and Monte Carlo ray tracing. Ray tracing and radiosity algorithms, currently implemented in image synthesis systems, provide the necessary rendering quality, but these methods are suffering from their extensive computational costs, and their enormous need for memory. The use of scalable parallel systems offers a solution to these problems.

The main result of the presented work is the development of two different data-parallel progressive refinement radiosity methods. These methods perform efficient parallel global illumination calculations in very complex architectural environments.

For common modeling systems the paradigm *modeling then rendering* is valid. In these systems the processes of modeling and rendering are strictly separated. The image synthesis system introduced in this thesis, tries to change this paradigm to *modeling while rendering*. The user is allowed to interact with the objects of the environment, e.g. turn on/off light sources, move objects, change materials, and after each interaction the primary influences of the modification of the scene on the global illumination are displayed with short delay. The introduced data-parallel radiosity methods were modified in order to calculate radiosity solutions in dynamic environments.

One goal of global illumination algorithms is the simulation of lighting effects caused by the movement of light photons in a given environment. The developed data-parallel radiosity methods are taking into account very complex light transport paths, which are not considered by classical radiosity algorithms. This is achieved by calculating extended form factors, and by performing a two-pass simulation.

In this thesis an image synthesis system is presented, which utilizes efficient parallel methods for solving the global illumination problem. The developed parallel global illumination methods have been implemented and integrated into an interactive image synthesis system. It is therefore possible to simulate global illumination effects caused by specular and diffuse inter-object reflection. The system is developed as a modular client-server architecture, which combines the advantages of graphic display acceleration hardware and parallel computing systems.

High Performance Computing systems have traditionally been used by universities, national laboratories and large companies for scientific and engineering "number crunching". These machines are much to expensive for architects and small companies. In this thesis a remote parallel rendering system is described which provides a framework for advanced electronic commerce applications. The system enables calculations of photo-realistic visualizations on demand by the use of advanced high performance computing technology. A remote parallel rendering service is offered over the Internet. Thus, the end-user has a cost-efficient access to hpc-systems, and so even small companies can profit from powerful systems which are too expensive for a local installation. The architecture of the remote rendering system as well as different end-user scenarios and applications of the e-commerce service are described in this thesis.