M2 internship at LIGM, Paris Est

Title: Geometric Approximations for Efficient and Accurate Global Illumination.

Supervisors:
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The internship would be located at the LIGM laboratory (ligm.u-pem.fr/). The expected outcome is a research paper, ideally ready for the EUROGRAPHICS 2017 submission. This project is part of a bigger project PAPYRUS (jointly with other institutes, including Ubisoft). PhD funding is available to continue the work started in this internship (funded by PAPYRUS).

The student is expected to have solid programming skills in C++, as well as a good background in probability and data structures.

Context: Rendering in the field of Computer Graphics is the following problem: given a 3D geometric scene (of piece-wise linear meshes, consisting of millions of triangles), several light sources and a camera, compute a 2D image as seen from the camera. Rough approximations can be computed quickly with rasterization based methods (e.g., using OpenGL). On the other hand, photo-realistic images are best captured using ray tracing, which can compute global illumination effects – shadows, color bleeding, reflections, glass effects and so on.

Several methods have been proposed to solve the global illumination problem, towards the ultimate goal of efficient and realistic rendering of large scenes in the presence of varied and complex lighting effects. Path tracing seeks to follow routes of light rays to compute their effects on pixels in the scene; in practice this method uses Monte Carlo sampling to speedup the potentially never-ending bounces of lights and thus converges very slowly to the optimal image. Another increasingly popular one is the many-lights technique for capturing global illumination: by tracing light paths from light sources, it creates virtual point lights (VPLs) at the intersections of the surface of the scene and the path. Global illumination is estimated by computing the direct illumination from all of the VPLs. However, as the number of VPLs needed for a good-quality approximation is large, computing the illumination for each point by summing up the contribution of each individual VPL can become prohibitively expensive.

Several methods and ideas have been put forth to compute approximately global illumination using VPLs, towards maximizing accuracy and efficiency of these methods. Two such examples:

— Sampling-based methods. First construct a distribution on the millions of VPLs on the scene. Then, for each pixel to be colored, instead of computing the contribution
from each of the millions of VPLs, sample VPLs according to the distribution, and use only their contribution (see, e.g., [3] for VPLs and [5] for path tracing).

— Clustering-based methods. For each pixel to be colored, compute first a clustering of the set of all VPLs, and then pick a representative VPL from each cluster and color the pixel using only the representative VPLs from each cluster (see, e.g., [2]).

Goals: Recent works in global illumination have initiated a systematic exploration in using the structure of geometry for global illumination, in both VPLs based methods as well as path tracing (including bidirectional path tracing) based methods. For example, in [1, 2] a compact geometric structure known as the well separated pair decomposition has been used for VPL-based methods, while in [4] geometric skeletonization methods related to the medial axis of geometric objects were utilized for improved bidirectional path tracing.

While considerable progress has been achieved in the past 10 years, current state-of-the-art methods are still not real-time, and with errors in scenes with complex visibility and lighting. For example, the figure on the right shows an image computing using the methods in [2], with the error shown below (the lighter the color, the higher the error).

The overall goal of this project is to continue the exploration of geometric structure based methods in global illumination, in both VPL and path-tracing based techniques.

References


