Dimensional Analysis of Light Transport Operators

This PhD thesis will last 36 months, and starts in September or October 2017.

It is funded by the french ANR project **CaLiTrOp**.

The student will be working at **INRIA Rhone-Alpes**, near Grenoble, France. Advisor: **Cyril Soler**.

Salary: about 1600 EUR per month (all taxes off).

Work plan

This PhD aims at studying the dimension of light transport operators between the infinite dimensional function spaces of light distributions (imagine, e.g., reflectance as an operator that transforms a distribution of incident light into a distribution of reflected light). In addition to be linear in these spaces, these operators are also very sparse. As a side effect, the sub-spaces of light distributions that are actually relevant during the computation of a global illumination solution always boil down to a low dimensional manifold embedded in the full space of light distributions. Reflectance over ''smooth'' materials for instance, converts incident illumination into a low dimensional set of reflected light distributions.

A first part of the work will consists in linking existing work on dimensionality analysis of light transport to the literature of eigenanalysis of Fredholm operators and resolvent theory. Simultaneously, a set of experiments will be conducted to figure out what the eigenspaces of the different operators look like. In a second step, the connection to Monte-Carlo eigenanalysis methods will be made, in order to create a generic method to compute the eigenfunctions of the transport operator in most general scenes.

In parallel, we want to leverage recent non linear dimensionality reduction methods such as Gaussian processes to implicitly parameterize low dimensional manifolds of light distributions or light operators. These parameterizations will be used to speed up computation, modification, capture and compress light distributions and light transport operators.

Expected results:

- a theoretical understanding of the dimensionality and structure of light transport operators (examples include scattering, reflectance, global transport in glossy scenes). Possible applications will cover re-lighting, material acquisition and efficient simulation of complex light transport problems.
- We also envision that controlled approximations of the low dimensional operators will open the way to efficient approximations of light transport which may also be suitable for real time applications such as interactive lighting for video games.

Proposed steps and sub-projects:

1. survey of existing literature about dimensionnality of light transport, across the domains of lighting simulation, Fredholm operators and harmonic analysis. Explore the connexion to resolvent theory. Possibly write a state of the art report.
2. find a practical way to compute the eigenfunctions of the global light transport operator. Connect with recent work on Monte-Carlo methods for SVD and eigenanalysis
3. explore the applications to eigenanalysis of LT for fast rendering

4. try ad-hoc methods for parameterizing the low dimensional manifold of operator output light distributions, and explore the applications to instant global illumination for video games.

The PhD candidate should have a solid background in mathematics and computer graphics, and be proficient in C++. Knowledge in GPU programming is a plus but not required. The candidate should speak english or french.

Application content:

- Letter of application
- Curriculum vitae
- School report
- References or letters of recommendation

Contact

Send CV and application letter before July 13th at *cyril.soler - at - inria.fr*