Diplomarbeitspräsentation

Interactive, Progressive Photon Tracing using a Multi-Resolution Image-Filtering Approach

Masterstudium:
Visual Computing

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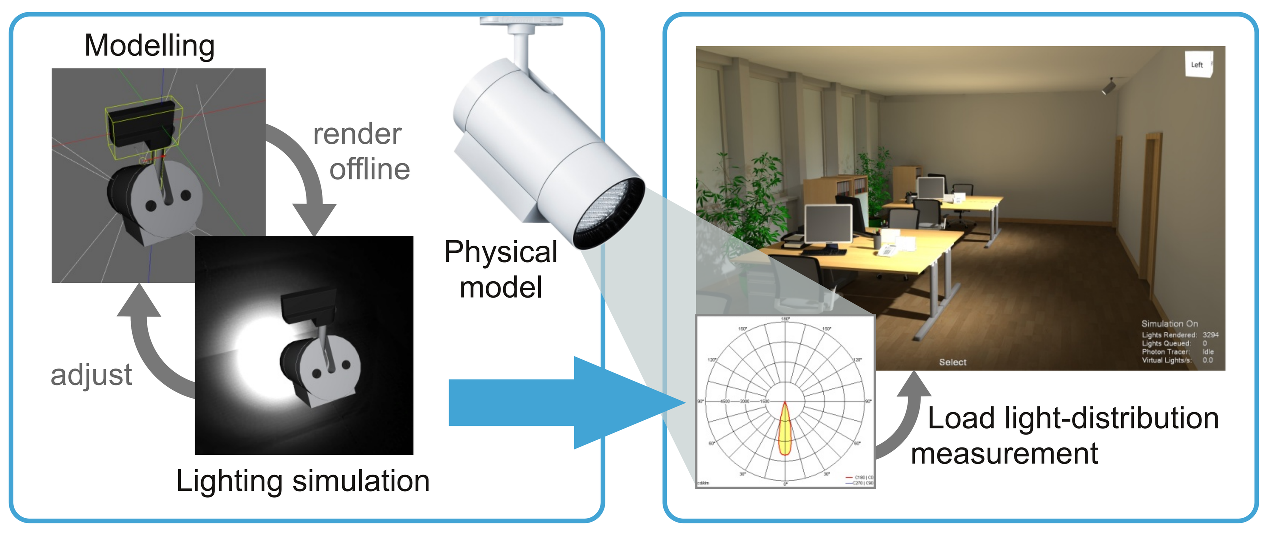
Context

Modern workflows in architectural planning and lighting design require physically reliable lighting simulations for very detailed and complex 3D models.

This master thesis project was created in context of HILITE, a light planning software developed at VRVis (together with Zumtobel Lighting GmbH), which allows lighting designers to interactively develop a lighting concept for architectural scenes by loading 3D models and placing light sources in the scene while the illumination is being calculated and progressively refined.

Motivation & Problem



During **luminaire design**, CAD programs are used for modelling the luminaire. Time-intensive offline rendering is used to accurately calculate the light distribution.

In **lighting design**, light concepts are explored by placing light sources in a 3D scene using an interactive light-planning software.

Current workflows for luminaire design and lighting design are not tailored to each oter.

After a luminaire is built, the light distribution of the physical model is measured to obtain a light distribution curve that can be imported to serve as light source in a light planning software. During the lighting-design process, it is not possible to modify the light sources themselves.

Interactive solutions that **seamlessly integrate luimnaire and lighting design** are needed to create a combined workflow that is more flexible and faster, reducing both production time and cost.

Approach

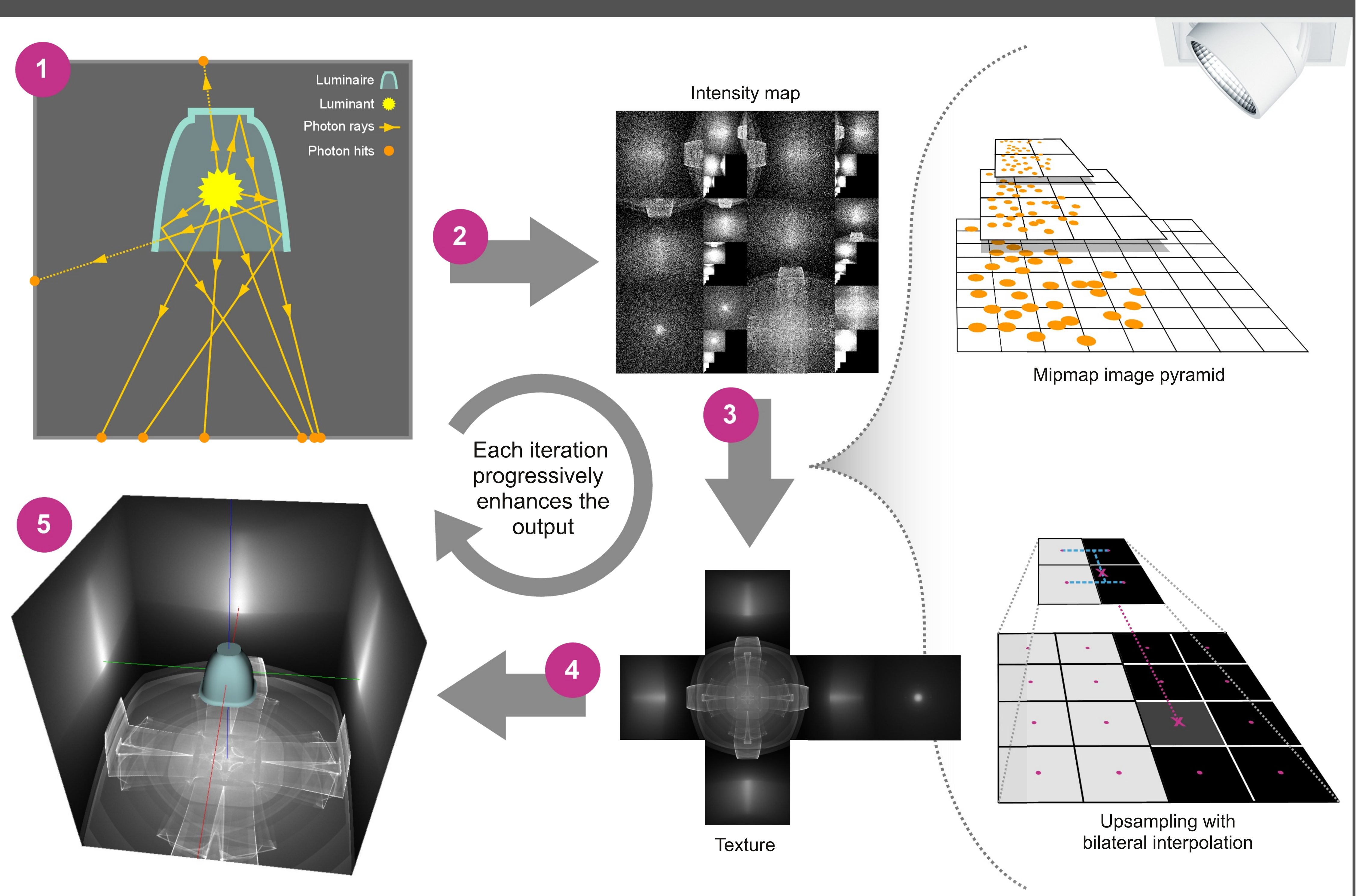
1 Our algorithm is based on **photon tracing** and works iteratively. In each iteration a number of rays are cast from the luminant into the scene. Rays are diffusely or perfectly reflected or transmitted, according to the surface material properties.

2 We use a cube map texture, called "intensity map", to **store photon hits per texel**. When a ray hits the surrounding cube, the photon count in the intensity map at the corresponding position is increased.

3 To be able to display **visually pleasing previews** in the render view, we need to turn the sparse, noisy intensity map into a smooth texture by applying our multi-resolution image-filtering approach. We developed a pull-push algorithm that uses different resolutions of the intensity map. **Pull phase**: Values of the higher resolution textures are summed up to get approximations for lower resolutions (creating a mipmap image pyramid). **Push phase**: We process one mipmap level at a time, advancing from low to high resolution. The photon count of each texel is compared to a user-defined global threshold. Texels that have a lower photon count than the threshold are upsampled by bilaterally interpolating the neighboring texels from the lower resolution mipmap level.

4 The resulting image-filtered cube map texture represents the **light distribution** of the luminaire and is displayed in the 3D render view and updated in each iteration.

5 This iterative algorithm enables the user to **interactively modify** the scene geometry (translate, rotate, scale) or material properties (diffuse, specular, perfect reflection or translucency) and see the effects as soon as the next iteration of the light simulation starts.

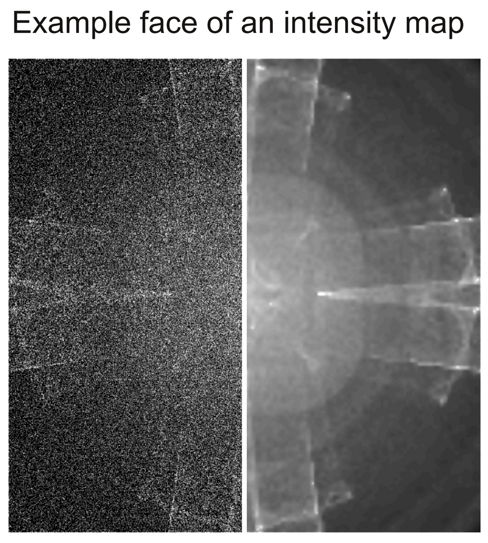


Results

We developed an interactive global-illumination algorithm that simulates the light distribution of a light source and produces visually pleasing intermediate results at **interactive framerates** before it **converges to a physically plausible solution**, resulting in a visualization of the light distribution of a luminaire.

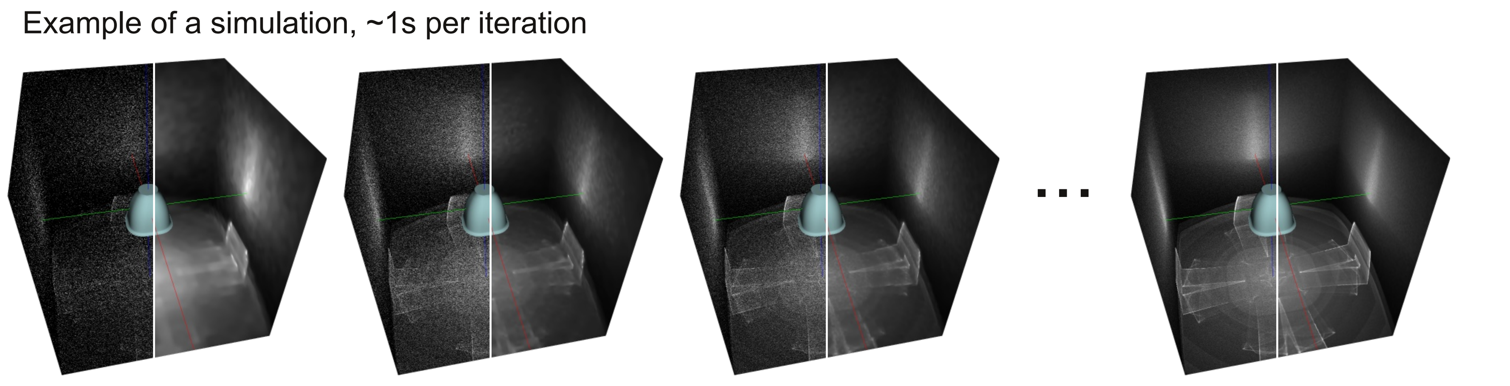
We combined an interactive, progressive photon tracing algorithm with a multi-resolution image-filtering approach that significantly enhances the output when compared to non-filtered textures. After only a few iterations, a **visually pleasing preview** is generated.

Example face of an intensity map



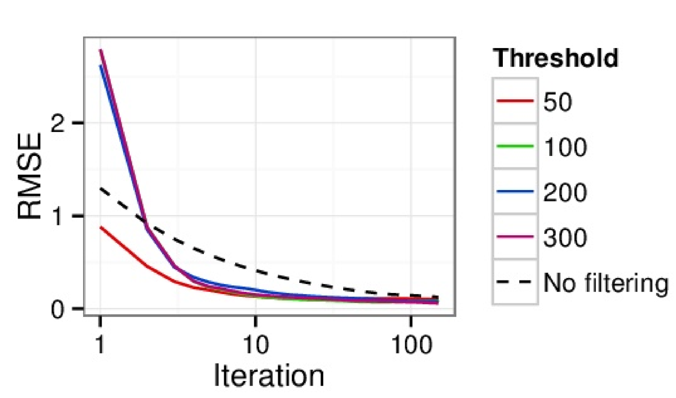
pure photon tracing | with mulit-resolution image filtering

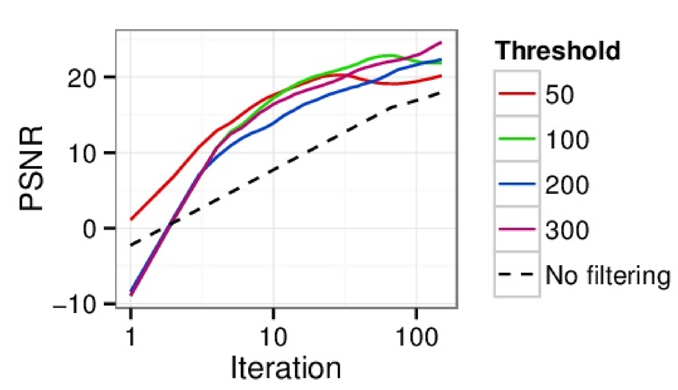
Example of a simulation, ~1s per iteration



Iteration 1 | Iteration 5 | Iteration 10 | … | Iteration 100

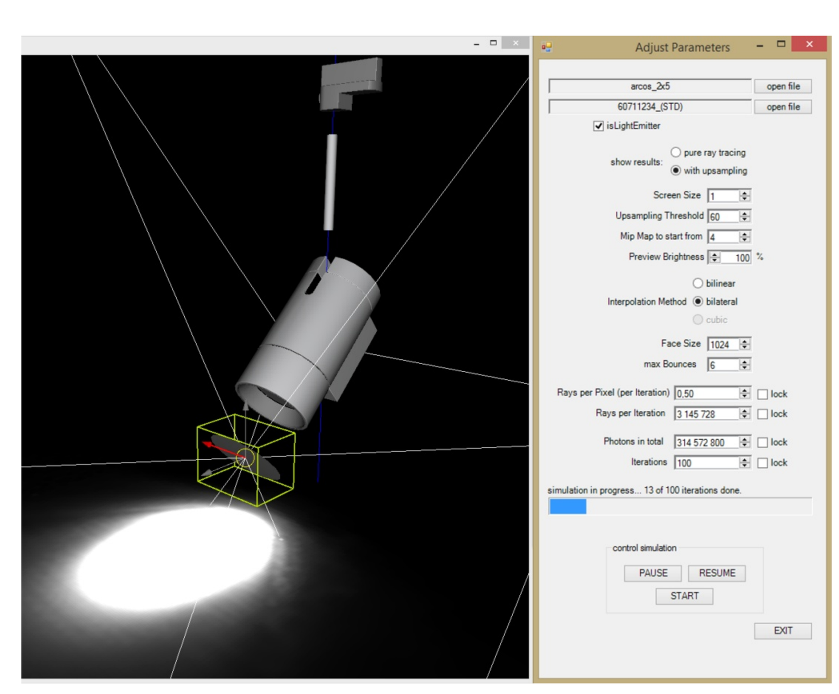
We compare the intermediate results, generated at each iteration with different thresholds, to a physically plausible reference image (obtained after several hours of rendering time), using typical **objective quality metrics.**





Luminaire Editor Prototype

A luminaire editor was developed as extension to the HILITE project. By providing fast previews, it allows the user to edit the luminaire in **real time**. The editor provides a multitude of parameters (for transformation of the geometry, modification of material properties, adaptation of rendering speed and image quality,..) and shows the **progress of the simulation**.



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