Radiance-Based Blender Add-On for Physically Accurate Rendering of Cultural Heritage

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Abstract

Despite the Cultural Heritage and Computer Graphics communities are increasingly joining forces to strengthen their collaboration, the study of how light interacts with monuments (e.g. weathering the surfaces or affecting the visitors' experience) is still an open problem in cultural heritage. A significant limitation is the lack of easy-to-use, open-source, physically-accurate tools allowing cultural heritage experts to perform lighting simulations on the increasing collection of 3D reconstructions. In this work, we present an open-source Blender add-on to facilitate such simulations. The add-on allows art historians to configure the properties (materials, lights, and camera) of the simulation, and uses as rendering back-end the Radiance software, a validated physically accurate light simulation tool. Our tool lowers the entry barrier for the use of a highly accurate but rather complex (command-based) tool for lighting studies in cultural heritage monuments.

CCS Concepts

• ***Human-centered computing*** → *Visualization systems and tools;* • ***Computing methodologies*** → ***Rendering;***

1. Introduction

In the last few decades, Visual Computing tools have been increasingly adopted by the cultural heritage (CH) community for their daily work. The recent advances in 3D digitization technologies have also fostered the adoption of digital tools for the analysis, documentation, interpretation, and communication of cultural heritage. An important area of study in CH is concerned with the study of the light in monuments [MPBG*22]. Such lighting studies allow art historians to understand the effect of weathering processes, as well as to validate different hypotheses about the role of natural and artificial light in the monuments' design, decoration, and use. For example, recurrent problems in art history involve the diachronic analysis of how light might have influenced the experience of the clergy and the laity during liturgical ceremonies, or how monuments and mural decorations were designed to let the natural light highlight certain iconographic elements on specific dates.

Despite the advances in photorealistic rendering, very few open-source tools provide physically accurate, predictive renderings fulfilling the strict color reproduction fidelity requirements commonly found in certain art history problems. Radiance [LS21] is a well-known, physically validated tool for light simulation. It is widely used in architecture and civil engineering to estimate surface irradiance, and it is also a valuable tool for the study of the perception of daylit spaces [CWA19]. Unfortunately, its design as a set of command-line programs poses a high-entry barrier for non-technical users. In this paper, we present a tool allowing users to

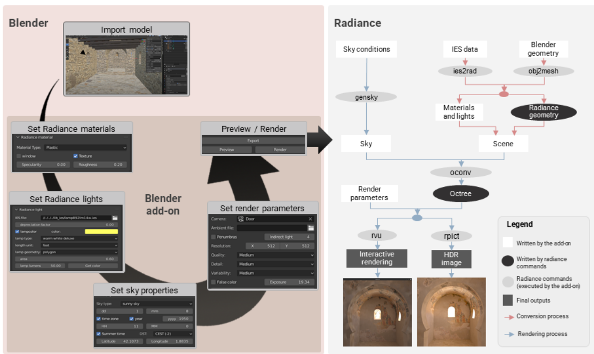

Figure 1: *Workflow of our tool: the user configures the simulation through menus, and our add-on automatically handles data conversion and Radiance commands' execution to get the final image.*

define the main simulation parameters required by Radiance (materials, artificial light sources, skylight, camera) using a simple GUI within Blender. The tool automatically translates the 3D model, materials, and lights into Radiance internal formats, and manages the execution of Radiance commands to obtain either an interactive preview or a high-quality HDR image. Our proposal simplifies the use of Radiance and thus can be a valuable tool for lowering the entry barrier of simulation software for the CH community.

DOI: 10.2312/egp.20231022

2. A Blender's add-on for Radiance

Figure 1 illustrates the process of defining and running a light simulation using our Blender add-on. The front end runs completely within Blender, whereas the rendering is (silently) performed by Radiance. The add-on basically allows users to set up the simulation in an intuitive way, translates the Blender scene and user inputs into Radiance's internal formats, and handles the different steps to actually perform the simulation.

Simulation set up Our add-on includes a collection of GUI panels that are fully integrated with the Blender interface. Once the user has imported the 3D model of a monument, the add-on allows the user to define how the Blender's materials should be translated into Radiance materials. The add-on supports all Radiance materials including plastic, metal, dielectric, glass, and mirror, as well as color-textured objects. Users can edit the properties (e.g. reflectance and transmittance) that characterize these materials. Similarly, the add-on allows users to set up light conditions. For artificial lighting, the user can assign an IES light profile to the light sources in the Blender scene, and configure their shape, color, and power. For natural lighting, users can use the GUI to set the sky conditions, including the date and time of the simulation, and the geographical location of the scene. Finally, the user can also define the camera and other rendering parameters.

Data conversion and simulation Once the simulation has been set up, the tool exports the Blender scene into files suitable for Radiance input. Several Radiance programs facilitate the automatic conversion of Blender scenes into Radiance-compatible formats such as `obj2mesh` (from a Wavefront .OBJ into a Radiance mesh) and `ies2rad` (from an IES light profile to a Radiance format). The add-on GUI discussed above collects the additional user input that is required by some commands, such as `gensky` (to simulate Sunlight) and `oconv` (to build an octree representation of the scene). The add-on GUI includes an *Export* button to export all the Blender scene data (geometry, materials, and lights), and *Preview/Render* buttons to generate the sky and the render settings, and then display the rendered preview interactively (using `rview` command) or generating a final rendered HRD image (using `rpict`).

3. Results

Our add-on allows users to easily manage lighting simulations with Radiance through a Blender interface with simple panels. The results are shown as irradiance measures or HDR images (see Figure 2). It allows users to simulate the lighting at any specific date-time (see Figure 3) and generates physically accurate lighting simulation images valuable for CH teams (see Figure 4).

4. Conclusions

We have proposed an easy-to-use Blender add-on to perform physically-accurate lighting simulations in CH. With a simple GUI, the tool shows the simulation results as HDR images or as irradiance measurements. This work represents a step towards facilitating the use of computer graphics results by art historians. We believe the tool can help them to better understand the original design and use of the monuments, as well as their weathering process. In the future, lighting tools for CH should allow users to test hypotheses (such as the influence of combustion materials or airflows) and generate validated images with very GUI's. Our tool is available at `https://github.com/miriam-mendez/Pedret`.

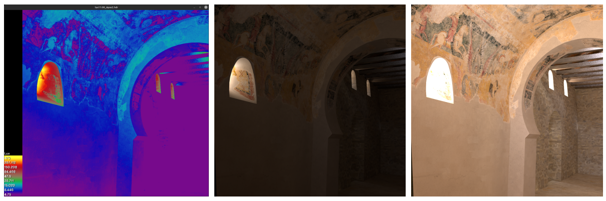

Figure 2: *Our add-on produces light measurements on the surface (left) and HDR images (low-key, middle; high-key, right).*

Figure 3: *Lighting differences at different moments: August 1st, from 12:00 (left) to 15:00 (right).*

Acknowledgments Work supported by projects PID2021-122136OB-C21 (MCIN/AEI/10.13039/501100011033/FEDER, UE), and EHEM (JPICH-0127, PCI2020-111979).

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Figure 4: *Physically accurate simulations on a medieval church.*