Visualising Lighting for Cultural Arts and Heritage Projects – Our Experience

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Learning Objectives

- Discover the importance of understanding and using accurate photometric lighting setups in 3D models for sensitive project spaces.
- How reality capture capabilities can be used to help model intricate spaces and details on heritage projects.
- Understand how working with ‘virtual’ lighting mock-ups in conjunction with a lighting designer refines the lighting design process.
- Discover the value of using 3D and interactive visualization for engaging with and enabling decision making for heritage stakeholders and clients.

Description

Lighting design has always been a difficult discipline to communicate; it’s a challenge for clients and project teams to produce the lighting design in their mind’s eye. This is especially applicable with refurbishment of cultural arts and heritage projects, where the complexity and intricacy of such internal spaces makes the way in which light interacts with surfaces and finishes particularly difficult to convey. From the outset, we’ve been keen advocates of using visualization tools, such as 3ds Max software, to demonstrate the lighting approach with clarity and photometric accuracy, using a range of 3D mediums—from traditional “static” images to in-house developed interactive tools and experimentation in VR, we’ll provide an overview of our visualization process through selected case studies of our heritage projects for the likes of Historic Royal Palaces UK, as well as University of Cambridge and University of Oxford.

Speakers

Karam Bhamra has over 17 years experience working in 3D Visualisation within the architectural and construction industry and originally comes from a graphic design and interior design background having studied both (respectively) at degree and masters level. Having initially joined Hoare Lea as a graduate, Karam spent 5 years training as Lighting Designer where he accumulated a wealth of experience in the niche specialism of Lighting Visualisation,
before leading the setup of their in-house CGI team where his team continued to develop engaging tools and techniques for visually representing lighting proposals to clients. Karam’s current role is as Immersive Lead with Hoare Lea in the developing area of Interactive & Immersive Visualisation content, where his team explore using 3D visual content in the form of Interactive Applications, Virtual / Augmented Experiences for improving and enhancing design communication and processes within built environment projects.

**Chris Lane** has 12 years experience working in 3D visualisation. Joining Hoare Lea in 2013 after spending 5 years as a lead designer at an exhibition/interior design firm, this experience has provided Chris with a more creative and interactive approach to his work, whilst also developing a keen eye for detail. CGI is more of a passion to Chris than a Job. What once was a hobby is now a full time career, and he is now part of a team that creates award winning realistic and immersive content to help convey complexity in a more intuitive, easy to understand experience for all kinds of sectors.

**Discover the importance of understanding and using accurate photometric lighting setups in 3D models for sensitive project spaces.**

Today most of us use 3D rendering at all stages of design, but are images being created a correct interpretation of the design intent? Are the material reflectances setup correcty and is the lighting setup photometrically accurate?

During the concept stages of a design, its understandable that an artistic approach is probably more desirable. However, when it comes to higly sensitive project spaces for arts & heritage buildings, which are often of historical importance and grade listed, accurate visual representation is an extremely important factor in the decision making process. Heritage buildings are under strict listed building regulations, which means its very costly for the stakeholders to make any alterations to these spaces. With visualisation based on accurate photometric lighting, crucial real-world decisions can be made on the restoration and refurbishment of finishes and materils in a digitally representation of the project space, before spending large sums of money.

**What is Photometric lighting?**

The correct setup of photometric lighting has always remained a key element in our workflow. Photometric lighting uses data provided by lighting manufacturers in the form of IES or EULUMDAT format files. These files contain the numerical data required to re-create the specific 3D distribution of light pattern created by at specific lighting product. It’s the measurement of light output intensity and fall-off in 360 degrees, containing fixed information about the direction, angle and distance the light travels from the ‘light emitter’. Aswell as this, using photometric data allows the capability to specify what total lumen output and colour tempretures are required - within actual real world values of the actual lighting product.
The images below (fig.1) show a visual representation (using IES Viewer) of photometric data for a typical spot light product. On the left you can see information about the lights output and also the ‘polar curve’ which demonstrates the shape of the lights output. A rendered representation of the light pattern can be seen on the right.

How to use Photometric lighting.

The correct setup of photometric lighting in 3dsMax firstly relies on using the correct IES file(s) for products as specified in a ‘designed’ lighting scheme. Secondly, there needs to be an understanding of how to setup the correct material properties for architectural surfaces within the space. The third part of equation is the rendering plugin used to raytrace the required rendered views. In our workflow we use Vray for all our raytracing of lighting visualisations. Mastering an understanding of how these 3 elements are co-dependent on each other and how to set them up within real-world tolerences, is crucial in achieving a correctly calculated image (as possible). An added bonus unique to our workflow is the fact we work in correalation with specialist lighting designers to iteratively achieve the best results possible.

The following images present an example of a model received that was lit in a rudimental fashion. Area lights and directional lights have been used to ‘fill’ the space with light from ‘expected’ sources such as the windows or ceiling suspended pendents (fig.2). In addition to this, the surface materials in the modelled space do not have any diffuse reflectances applied the them. The resulting render (fig.3) presents an inaccurate view of how this space would look in reality. The lighting is ‘too’ balanced in an unrealistic way, where every area within the space is generally lit, while all the surfaces reflect the same amount of light and therefore appear to look very similar regardless of the applied textures.
However with the correct lighting setup, based on a design scheme and real-world values for both the lighting products and material properties (fig.4), the resulting renders present a very different and more accurate representation of the space (fig.5).
Material setup directly effects rendered lighting appearance.

As shown in the previous example - without the correct material setup, the lighting wont appear in the space as it would in reality. There are some key elements in our process for insuring that the material is as accurately represented as possible;

- Diffuse reflectance - in Vray this can be controlled by adjusting the RGB multiplier in the bitmap settings plugged into the diffuse channel or by lowering the RGB value using a colour correction node. Lowering the number effectively reduces the amount of light being scattered from the surface.
- Specular reflections – How glossy is the surface, and does it have the correct IOR value applied depending on the type of material.
- Use of real world reference images of the actual material (being recreated) in different lighting conditions to aid in getting the above parameters correct.

The images below show the same IES lighting setup with exactly the same real world values in each scene. However it would ‘appear’ that the light levels are different between the two scenes, this would be greatly mis-leading to any stakeholders having to make a decision on the space or lighting proposal based on what they are seeing (fig.6).

The image on the left shows the ground material with a diffuse reflectance of approx. 20% (0.2) and the light column reflectance set to 40% (0.4). The image on the right shows the ground material diffuse set to approx. 50% and the column set to 10% (0.1).

This demonstrates the importance that correct material diffuse levels can have on the lit impression of lighting in rendered visualisations.
Our typical photometric lighting visualisation workflow.

Below are the key steps in our typical process for ensuring a 3DSmax scene achieves an accurate photometric lighting setup;

1. **Only use a full photometric lighting setup**
   - Work with the Lighting Designer and use their provided scheme design layouts and product specifications.
   - Source IES files for either existing known or specified lighting products
   - Correct beam-angles, position, orientation and direction of INDIVIDUAL lighting products
   - Real-world values for lumen output, colour temperatures / RGB values

2. **ALL scene materials using the appropriate surface reflectance values (diffuse levels)**
   - Setup typical known values for commonly used architectural materials
   - Making adjustments based on condition / age of materials in the real-world space

3. **Only use real-world camera exposure**
   - As long as ALL photometric lighting values in the scene is correctly setup then any discrepancies where artificial lighting looks to ‘dim’ or ‘blown out’ should ONLY be corrected through adjusting exposure levels - never by multiplying IES outputs

4. **Draft renders and iterations**
   - Use a physically based raytracing plugin for calculating the photometric lighting – we use Vray with some customised brute force based render settings for an accurate result as possible.
   - Analyse the visual appearance of the lighting in your drafts, NOT looking to improve the aesthetic of the visuals, but looking to check for any errors in the behaviour of the imported lighting data – just because an IES file came from the a manufacturer and all the real-world values and specifications provided were input to 3dsMAX, doesn’t guarantee that the results rendered are correct.
   - Make any required adjustments / iterations while working in conjunction with the Lighting Designer – using the real-time preview in the 3dsMAX viewports is perfect for this process.

5. **Final render & post-production**
   - If any post work is required to enhance the images, this should avoid changing the overall lighting levels or balance within the images – the aim of lighting visuals is to show how the space will appear under realistic lighting conditions.
How reality capture capabilities can be used to help model intricate spaces and details on heritage projects.

To get a better understanding of how we can use reality capture tools and references to improve modelling intricate parts of arts and heritage spaces we will look at two previous projects we worked on at Kensington Palace and Oriel College, both of which are over 400 years old and at the time had no existing 3D model or 2D CAD data available.

With these types of spaces, acquiring good quality photography as well as 3D capture of the space is invaluable and a must. The 3D captured point cloud data in particular provides a level of information which allows us to have a clearer understanding of the architectural details and hard to reach areas within heritage spaces.

The image below shows a pointcloud generated from a 3D capture that was taken at the Cupola Room at Kensington Palace (fig.7).
Using pointcloud to help manually build 3D geometry.

This pointcloud data can be imported into 3ds Max as a .rcp file, and then manipulated with a limit box, allowing us to only see the parts that we are interested in. This data can help provide accurate dimensions of particular objects in the space, where we can use the pointcloud essentially like ‘tracing paper’ to model around giving us certainty that those shapes are the right scale as well as positioned correctly in the space.

The image below was taken from the Oriel College 3dsMax scene, where a portion of the pointcloud has been imported and limited with a box so that we can focus on modelling the roof structural elements (fig.8).

![Fig. 8](image1)

Here we see the resulting roof structure geometry modelled using the point cloud data as a base (fig.9).

![Fig. 9](image2)
These images show us using the point cloud to model up the music box / clock feature which sits in the centre of the Cupola room. Essentially we are ‘tracing’ the captured surface points and manipulating the 3D geometry to fit them as accurately as possible to progressively build up the element in full 3D geometry (fig.10).

As well as using the pointcloud to manually create 3D geometry, we can use meshing software (such as Re-Cap pro & Mesh Lab) to help us automatically generate geometry from the pointcloud data. This process is a little more ‘push the button and see what you get!’ so results can vary, but it can massively speed up the process of modelling more organic shapes such as statues. We can take the models generated in this way and do some further manual clean up of the geometry. With clever use of photographed textures we can also cover up any anomalies and create what looks like a highly detailed 3D object in the model scene (fig.11).
Creating textures from photographic references.

When working on visualisations for heritage projects, visiting the site in person is the most useful thing you can do before creating the materials for the space. Whilst on site, taking photos with quality camera and correct exposure setup helps provide the necessary reference to re-create materials in the space.

Tips for taking usable images on site;
- Use a high resolution camera (DSLR or Mirrorless camera preferred).
- Use a high F-stop number to ensure the image is in focus (f5.6 minimum).
- Use a tripod where possible to allow the use of lower shutter speeds to keep the ISO down, reducing noise.
- Use the correct White Balance.
- Avoid conditions where direct artificial/daylight is creating deep shadowing or highlights on surfaces – it’s difficult to avoid all shadows or light completely in any space.

With images taken in this way, we can process them further using photomanipulation software to balance out any anomalies in light/shadow contrast and create suitable texture maps for applying to 3D geometry as build the scene in 3dsMax (fig.12).
Understand how working with ‘virtual’ lighting mock-ups in conjunction with a lighting designer refines the lighting design process.

**Physical lighting mock-ups vs digital lighting mock-ups.**

Whilst working with ‘real-world’ lighting mock ups is still a requirement for sensitive lighting design projects, it has certain limitations in terms of helping the lighting designer make decisions for their proposals. For example they can usually only have a limited number of light fittings they can test at the project site at one time, so never quite get to see if the full treatment of lighting to the space will give the desired effect they envisage.

Using our photometric lighting workflow in 3D space, we can create lighting mock-ups digitally to help the lighting designer ‘fully explore’ options and iterations to their design proposals much faster then they can with the physical mock up and much less cost and labour.

However, this doesn’t make physical lighting mock ups obsolete, often the lighting designer will still as a first phase take sample products to site and test effects to make initial decisions on placement, beam angles, tilts etc (fig.13).

![Image](image_url)

*The image above left shows the lighting designer setting up a linear fitting positioned on top of the cornice to wash the ceiling. Where as the image on the right shows the tilt angle changed to push light more into the centre of the ceiling vault - the difference in effect is quite significant.***

Once the lighting designer has made some decisions for mounting the product, the recorded data is provided to us for the second phase where we generate a full digital mock up.
Testing on site this way can greatly influence the accuracy of how we setup the lighting in our 3D model. Below shows the typical lighting layouts and product specifications we are provided by the lighting designer (fig.14). This info contains all we need to for correct lighting ‘installation’ in our 3D scene (fig.15).
Sometimes physical mock ups just aren’t possible for a difficult to reach location or for a lighting element that does not yet physically exist, but is being proposed for the project space. For part of the scheme at the Cupola room (Kensington Palace) the proposal was to ‘invisibly’ integrate LED spot lights between the arms of the bespoke restored chandeliers, in order to aim at and highlight some of the features in the room, such as the statues and artwork detailing (fig.16).

The lighting designer couldn’t test how many spots would be required at where they would be aimed as the chandelier and rig for the spots were in production. So using the digital models we has built for this bespoke chandelier / spot arrangement, we created a setup a rig in 3dsMax which allowed the photometric lights to be easily adjusted / re-targeted in real-time. This meant that we could do a virtual mock up with the lighting designer in the 3D model (fig.17) allowing them to tweak the spotlight targeting and outputs (within the lighting products specification) until they had the desired effect (fig.18).
The final rendered views.

With all lighting in place, we produced to views for the Cupoa Room which were presented to stakeholders for sign-off of the lighting proposals.

View facing towards fireplace.
View facing the windows (opposite direction):
Using 3D and interactive visualization for engaging with and enabling decision making for heritage stakeholders and clients

Interactive LightSIM

As explained previously, making decisions on lighting and new décor schemes in arts and heritage buildings can be quite a tricky and expensive process. For this reason, sometimes we package up our final deliverable as an application, that the client / stakeholder can interact with. This is called a LightSIM, see image below;

This application allows the user to 'play' with the lighting, where they can dim / turn off certain treatments, change colour temperatures, rgb outputs, turn daylight on/off and creating different lighting scenarios of their own which could be used in different events.

This can also be used as a reviewing tool with the lighting designer, so they can create some preset scenes that can help for when the lighting gets commissioned into the space.

See the link below for a video on our vimeo page of how our interactive LightSIMs work; https://vimeo.com/164715976
VR Interactive

In terms of visualisation for lighting design in arts and heritage spaces, VR will benefit the way we and our clients make choices, by placing them in the environment it allows them to not just see the space, but experience it.

We can add controls to change material finishes, layouts and add tools similar to the LightSIM.

The two links below demonstrate different ways we have used VR to help with decision making. One shows how we can use VR to demonstrate different design options whilst the other allows the use to control the lighting in the space, similar to our LightSIM.

VR Residential: Design Options Explorer
https://vimeo.com/299901379

VR Hotel Corridor: Lighting Options Explorer
https://vimeo.com/300264722

3D rendering and the way in which we render light is always evolving. We are always looking into how new technology can impact the way we accurately portray a space, with new real-time raytracing hitting the scene, it will be interesting to see how hardware and software evolves to cater for these more complex lighting design requirements in the future.