Radiance Simulations and Visualisations with LiVi

For LiVi version 0.1

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Introduction

The Lighting Visualiser (LiVi) is an open-source add-on to the 3D modellign and animation package Blender, which acts as a pre/post-processor for the Radiance lighting simulation suite. LiVi allows for quick geometry creation and material specification via Blender, runs the Radiance simulation with user specified parameters, and imports the data back into Blender for visualisation. LiVi is capable of simulating static or animated geometry under steady state or transient natural lighting conditions. Daylight Factors, irradiance and illuminance, on any geometry within the scene, can be calculated. Background skies as illumination sources can be automatically generated with Radiance, or the user can use their own generated High Dynamic Range (HDR) light probes. The combination of LiVi, Blender and Radiance represents a streamlined and completely open-source lighting analysis work-flow that encourages the user to quickly and easily experiment with form and materiality, from within a professional visualisation environment.

Background

LiVi attempts to blur the distinction between software workflows that relate to the acquisition of building technical data, and the visual building design process. Almost all relevant software either falls into one of the two camps. Notable examples for the former are EcoTect and Design Builder, and of the latter Cinema 4D and 3D Studio Max. The existence of these two distinct camps, we believe, is a barrier to communication between the design and technical sides of the architectural discipline, and that enhancement of this communication is essential to deliver the environmentally responsible, and beautiful, buildings we increasingly require.

Although there are existing examples of this integration including 3DS Max Design, LiVi (along with Blender and Radiance) is free, open-source and aspires to an even greater level of integration. Material, form and and time animations set-up in Blender can be simulated with Radiance, and conversely the results from the radiance simulations can be expressed as 3D geometry within the blender scene, allowing them to be animated, rendered, fade in and out of view etc.

Why Blender? Well, in our opinion at least, Blender is the most professional, open-source 3D content creation suite available, and it becomes more professional by the day. It is also free and multi-platform which means there are no significant cost or hardware barriers to its use. Its open-source nature means that we can make minor changes to the source code to enhance the functionality of LiVi, and its use of Python as a scripting language, provides immense flexibility in terms of communication with other applications and the expression of the data from these other applications within Blender.

Finally, and quite recently, Blender has incorporated a new, physically based rendering engine called Cycles which allows accurate and interactive analysis of the visual lighting consequences of form and materiality decisions. Coupled with the ease with which these design choices can be assessed numerically with LiVi, the two provide a powerful and closely integrated approach to the ascetic and performance of lighting scenarios within and around buildings.

Installation

All the software to run LiVi is available from the LiVi website, which can be found at http://arts.brighton.ac.uk/research/office-for-spatial-research/projects2/livi. Currently LiVi can be run under Windows, OS X and Linux systems, although full animation functionality is not currently available for Windows. In the case of Windows and Mac OS X, LiVi is bundled with Blender and Radiance, which are also free and open source. The websites of these two packages can be found at http://www.blender.org and http://radsite.lbl.gov/radiance/ respectively. For Linux, only LiVi is provided as it assumed a Linux user will install Radiance and Blender independently. For full animation functionality minor changes are made to the Blender source code. This modified source code can also be downloaded from the LiVi website for compilation on a host system.

Mac OSX

LiVi has been tested on OS X Version 10.5 (leopard) and 10.6 (snow leopard). As all the required software tools are free and open-source they are included within a single archive file for ease of installation. The included version of Blender is a slightly modified 2.62 release to allow geometry and time based animations.

Once the main archive file has been downloaded it should be decompressed, and the resulting folder entitled blender-26 should be moved to the OSX main ’Applications’ directory. The Blender application icon within this folder can be moved to the launcher bar for easy starting.

It is also advisable to use a three-button mouse, which is set up as a three button mouse, in OS X.

Windows

LiVi has been tested on Windows 7 running in 32-bit mode. The folder within the downloadable zip archive can be placed anywhere, and to run Blender simply click on the Blender executable within the folder. At the time of writing the windows version of Blender supplied on the LiVi website does not have the source code changes applied to enable the full animation capabilities of LiVi, so only ’snapshot’ time, and ’static’ geometry analysis are functional.

Linux

For Linux only the LiVi scripts themselves are made available. Radiance and Blender can be installed via most common Linux packaging systems, and if compiling the modified Blender source code, instructions to do so can be found here.

Configuration

Running Blender icon should now launch the Blender interface, which should look similar to the one shown in figure 1. The main window is the 3D view where the default cube, lamp and camera can be seen. Below this is the animation timeline, on the top right is the project outliner that contains a list of everything in the scene and bottom right is the properties panel where much of the Blender functions reside. Detailed instructions on how to use Blender are beyond the scope of this document, but there are excellent beginners documents available by James Chronister, available here and by John Blain, available here. The former is meant for high school students so it takes a slightly younger approach. There is also a very comprehensive set of video tutorials available from here. In addition, there is a wealth of websites and You Tube and Vimeo videos dealing with many aspects of Blender’s capabilities.

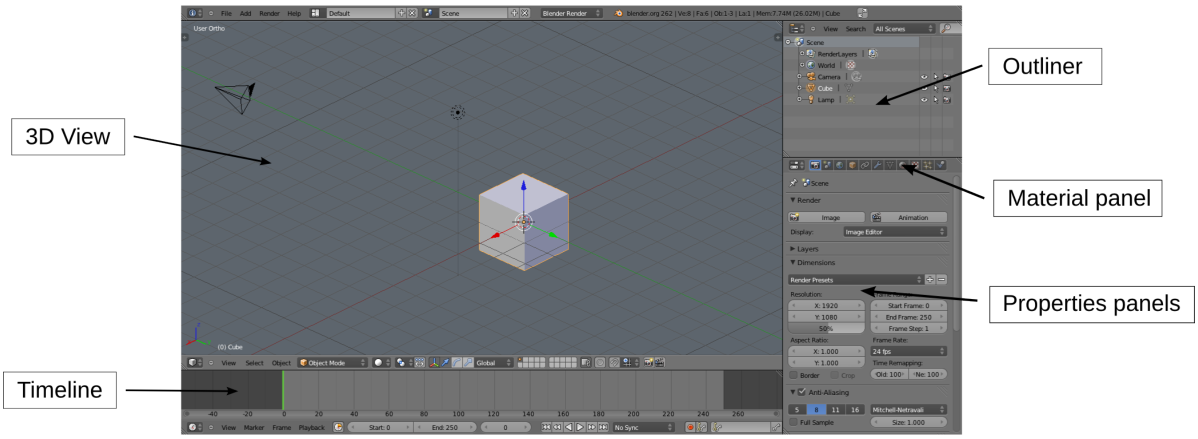

Figure 1: The default Blender interface

LiVi is an addon to Blender and will need to be activated on a fresh install. This can be done from Blender’s user preferences. Go to ’File’ menu at the top of the 3D view and from the drop down list select ’User Preferences’. Along the top of the new preferences window there will be an ’Add-on’ tab. Click on this and from the ’Import-Export’ list on the left select the ’Lighting Visualiser (LiVi)’. There are other settings within the ’User Preferences’ that can be altered as desired, for example to control how the 3D view is navigated. The resources above both contain sections on customising the Blender user interface. By default the 3D view can be rotated with the middle mouse button, zoomed with the mouse wheel and objects are selected with the right mouse button.

Once LiVi has been activated it sits within the 3D View Panel which, with the mouse over the 3D view, can be toggled on and off with the 'n' key. Alternatively you should see a small '+' sign in the top right of the 3D view. Clicking on this will also open the 3D view panel. At the bottom of this panel is the LiVi interface which should look something like figure 2.

The LiVi interface consists of three sections: LiVi Export, LiVi Calculate and LiVi Display, and as you might have guessed the first section controls the export of Blender data to the Radiance format, the second controls the Radiance calculation, and the third controls how Blender visualises the Radiance results. The sections are context sensitive so if the Blender scene has not been exported nothing will be available in the calculation or display panels. An exception to this is if a Blender file is opened that contains results within it from a previous simulation; the display panel will then be available in this case.

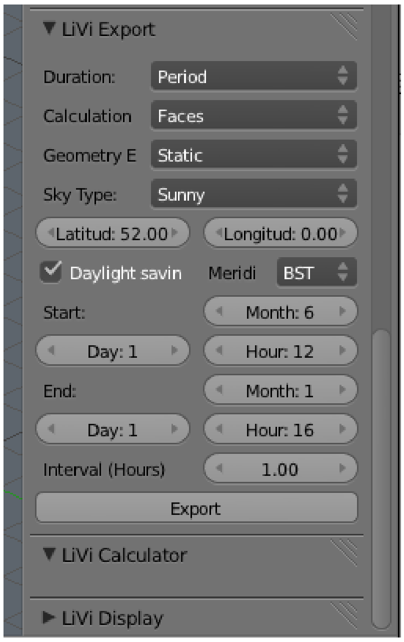

Figure 2: The LiVi Interface

Usage

Export

So, let's get stuck in and do our first Radiance simulation. If you do not have a default cube in the scene then press 'shift+c' to centre the view and then go to the 'Add' menu at the top of the 3D view and select 'Mesh - Cube'. The cube should be automatically selected but 'right-clicking' on it will make sure. Radiance needs to be told which geometric objects within the scene are to be the sensor points for the calculation, and to do this we give the desired geometry a material with the word 'calcsurf' in it. For this first simulation the faces of our defualt cube are going to be our sensor points. At the top of the properties panels section is a button for the material panel (shown in figure 1). Clicking on this button will reveal the material panel, which as the cube is hopefully selected, is specific to the cube material. If the cube has just been created it may have no material currently attached, or it may have the default material called 'Material' attached. If there is no material click on the 'New' button and the material pane should look roughly as it does in figure 3.

At the top of the material panel is s a list displaying all the materials associated with the object. At the moment there should be just one, the default material or the one just created. Below that is the material name, which is altered to contain the word 'calcsurf' to designate the object as a sensing location. Below this are the material characteristics which are altered not only to change its appearance in Blender, but to control what type of material description to send to Radiance for simulation; key sections of the panel are 'Mirror' and 'Transparency'.

Table 1 shows how Blender material characteristics are translated into Radiance materials. Going down the table the first Blender material condition that is met is the one that will be exported to Radiance, and the lower ones ignored. In addition the colour of objects specified in the 'Diffuse' and 'Specular' panels will automatically be exported to Radiance where appropriate. For the moment a plastic material is fine so make the cube diffuse colour as desired by clicking on the colour bar area of the diffuse panel, and make sure transparency and mirror are turned off. Save the Blender file by going to 'File - Save'.

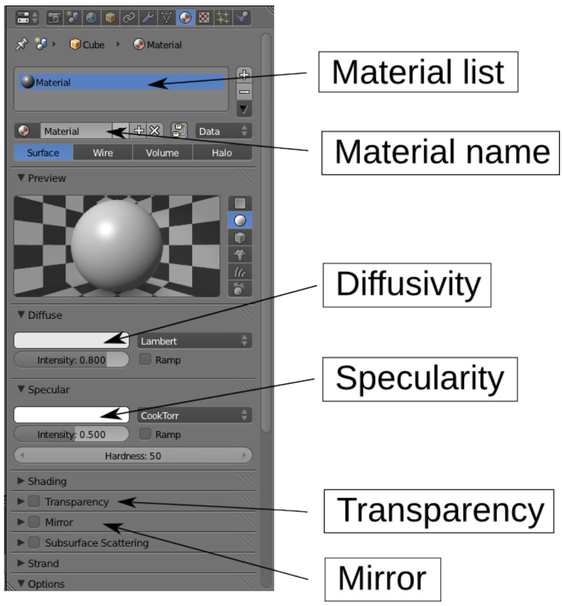

Figure 3: Material panel

Before the scene can be exported the settings in the LiVi Export panel should be altered for the simulation. The first setting is 'Duration' which controls whether the simulation is for a moment in time or for a period of time. Leave this at 'snapshot' for now. The next option is 'Calculation Points' where the nature of the sensor points on the object is controlled. 'Faces' means that the centre of the faces of the cube will be the sensor points, 'Vertices', or corners of the cube will be sensor points. Select 'Faces' for now. The next option is 'Geometry Export' which controls whether animated or static geometry is to be exported. Select 'Static' for now. The next option is 'Sky Type' where the nature of the natural light in the scene can be controlled. For now select 'Sunny'. Below these four options are options specific to the sky type created. In the case of a snapshot sunny sky, latitude, longitude, summer daylight saving and longitude meridian of the site can be selected (and can be left at their default values for now), along with the month day and hour of the year for simulation. Pick any time of year as long as the sun will be above the horizon at that time. As we are using a sky to illuminate our scene the default lamp in the scene is not required so can be selected with a 'right-click' and deleted by pressing 'x'. The scene can now be exported by clicking on the 'Export' button at the bottom of the LiVi Export panel. The interface will become unresponsive while the export takes place, a weakness in the current LiVi implementation which will be corrected in future versions, but should not take very long for this simple scene.

Blender material	Radiance material	Notes
Set 'Shading' - 'Shadeless'	Antimatter	An invisible material in Radiance. Good for calculation surfaces
Set 'Mirror' - 'Reflectivity' > 0.99	Mirror	Perfect mirror
Set 'Transparency' - 'Raytrace' -'Alpha' > 0.01 'IOR' = 1.52	Glass	Typical Glass
Set 'Transparency' - 'Raytrace' - 'Alpha' < 1.0, Set 'Translucency' > 0	Translucent	Lets through diffuse light
Set 'Transparency' - 'Raytrace' - 'Alpha' > 0.01 'IOR' not = 1.52	Dielectric	Similar to glass but with differing IOR
Set 'Mirror' - 'Reflectivity' < 0.99	Metal	Specular and diffuse reflections are the same colour
None of the above	Plastic	No strong reflections. Covers most materials.

Table 1: Blender - Radiance materials conversion

Geometry import

Although geometry can be created within Blender, if the user is used to creating geometry within another package, this geometry can be imported into Blender. In the 'Import-Export' section of thre 'Addons' user preferences panel the import of different file formats can be enabled. By default the import of Wavefront OBJ and 3DS should be enabled. Upon importing the geometry the scaling of the new object may be too large or small to be seen in Blender's default view. If this is the case press '.' on the keyboard numpad or go to the 'View' menu at the bottom of the 3D view and select 'View Selected'.

One the geometry is imported then if objects were defined as separate entities with separate materials in the original program they should be separate objects, with distinct materials, in Blender. The Materials may not be correct however and may need to be changed in Blender's material panel fr conversion to Radiance.

If a piece of existing geometry is desired as a sensing region, associate a material with 'calcsurf' in the title to that geometry. If a bespoke sensing plane is required then create a plane ('Add' - 'Mesh' - 'Plane') and manipulate it to the desired position. It is important that more than one face is designated as a sensing region when using the 'Faces' calculation points option, and as a new plane by default only has one face it is necessary to sub-divide it. A plane can be subdivided by pressing 'Tab' with the plane selected. This enters 'Edit' mode (It is useful to have the Tools panel visible for this operation, which can be toggled with the 't' key when the mouse is over the 3D view). The first drop-down menu at the bottom of the 3D View will say whether the current object is in 'Edit' or 'Object' mode. Once in 'Edit' mode pressing 'w' will bring up a specials menu. Selecting 'Subdivide' from the specials menu will split the plane once. Greater number of sub-divisions can be achieved by increasing the 'number of cuts' option that should now be visible at the bottom of the tools panel. Once the plane is sub-divided as required leave 'Edit' mode by pressing 'Tab' again. Associate a material with 'calcsurf' in the title to the plane.

Calculation

Once the scene has been exported the calculation panel should become active. The options within this panel control the lighting metric to be assessed ('Simulation Type') for which illuminance in Lux, irradiance in W/m^2 or Daylight Factor (if a DF Sky was selected) are currently available, and the simulation accuracy. Greater accuracy will generate more accurate lighting, taking into account more inter-reflections, but may take considerably longer. Select 'Irradiance' and 'Low'. There are two buttons below these options. The first allows a preview of the scene, as calculated by Radiance, to be viewed. This can be useful to check that the material definitions specified have been translated correctly into Radiance format. The scene will be previewed from the perspective of the Blender camera. To manipulate the camera into the desired position the 3D view can be manipulated to give the desired view and then from the bottom of the 3D view window select 'View - Align View - Align Active Camera to View'. This will then align the camera to the current view and view the scene through the camera. To break out of the camera view rotate with the middle mouse button (the camera will be left in its new position).

Once the camera is in position pressing the 'Radiance Preview' button will open up Radiance's visualisation window. This window may display an image that is totally white, black or other wise incorrectly exposed. The method to correct the exposure of the display is dependant on the operating system the software is being run on. On OS X and Linux, with the mouse over the window, press 'e - enter' and click somewhere on the window. This should normalise the exposure to the brightness of the part of the image clicked on. On Windows the menu entry 'Exposure' can be used to alter the image (lower the value to darken the image and increase it to brighten it).

Once the materials have been checked the preview window can be closed. Make sure the X11 application is totally closed, especially on OS X, as well and control will return to the Blender interface.

The simulate button tells radiance to calculate the lighting metric specified, at the points specified. When the calculation has finished, a message will pop up to say the calculation is finished. The Blender interface will again be unresponsive while simulating. The LiVi display panel should now be populated.

Display

In the LiVi display panel there is a display button, OpenGL toggle switch and 3D results toggle switch. The OpenGL toggle controls how the 3D view represents the scene. With the toggle on, the 3D View shows an OpenGL rendering of the scene, off it shows the regular 3D View. The 3D results toggle, when on, will make the results plane 3-dimensional when displayed and exposes the '3D Level' slider which controls the level of 3D distortion of the results plane each time the display button is pressed. Pressing the 'Display' button will colour code the results plane, and bring up a legend in the 3D view to relate the colour to metric values. Above the legend should appear some simple statistic about the results. The background colour of the OpenGL 3D view can be changed in the 'World' tab in the properties panel with the 'Horizon Colour' setting.

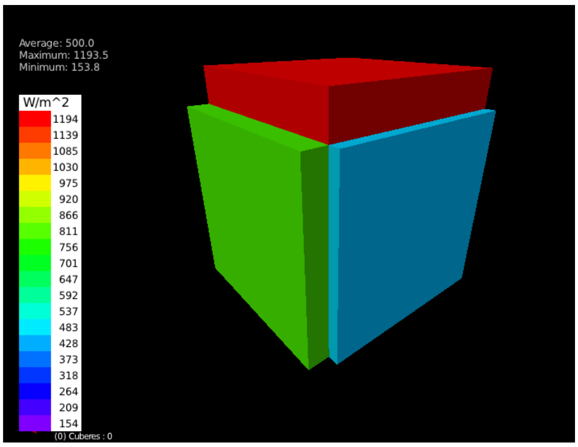

Figure 4: Results visualisation

In the case of the default cube the sides of the cube should have changed colour to correctly relate to the legend key. If the 3D results setting was selected, the sides of the cube should have been extruded by an amount proportional to the result on that face and the 3D level set in the LiVi interface, and may look something like figure 4.

If a dynamic simulation, either time or geometry, was requested then the resulting animation of the results can be viewed by pressing 'alt - a' ('esc' will halt playback). Or each frame of the animation can be stepped

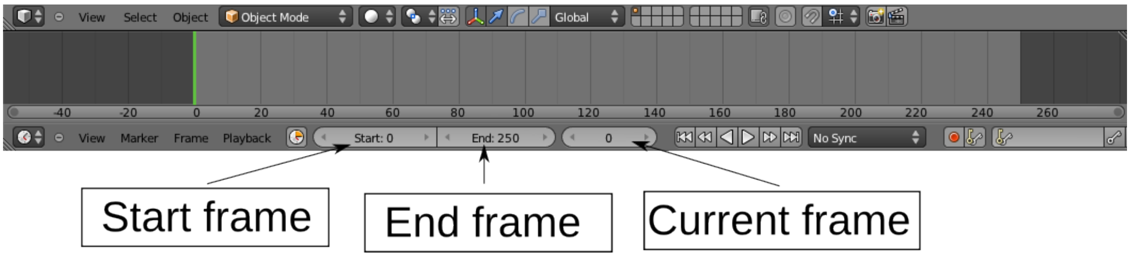

Figure 5: Animation timeline

through by pressing the left and right arrow keys. The total frame range and the current frame are shown at the bottom of the screen in the animation time line window (figure 5).

To generate static images of the results a screen grab incorporating the 3D view is probably the simplest method and will automatically include the legend and statistics display in the window. Alternatively the OpenGL view can be rendered to an image with the camera icon situated on the bottom right of the 3D View. After the rendered image is complete press 'F3' to open a file save dialogue. If a dynamic simulation was run, and an animation of the results desired then the clapper-board icon , next to the camera icon, can be used. The location and type of animation saved is controlled in the 'Render' properties panel in the 'Output' section. Using these OpenGL renders loses the the legend display, so a screen-grab of the 3D view, and cropping the image down to the legend generates an image that can be superimposed onto the rendered image with an image editing tool.

Rendering with Blender Internal

Blender has a internal rendering engine which can produce very satisfactory results for exterior scenes, but mileage varies for internal shots. To render the camera view Press the 'Image' button in the 'Render' section of the 'Render' properties panel. If an animation of a dynamic simulation is required press 'Animation' instead. In the 'Output' section of the render panel you can choose the format and save location of the still image or animation. The image should appear in the main window of Blender. Bear in mind that the render is done from the camera viewpoint and not the 3D View viewpoint.

Rendering with Cycles

Blender's new rendering engine, Cycles, can be used to render out the scene from a visual, rather than a numerical, perspective. Cycles, like LiVi, is activated in the add-ons panel within the user preferences, but instead of the the 'Import-Export' section of the add-ons Cycles is in 'Render' section and called 'Cycles Render Engine'. Once Cycles has been activated and the preferences window closed the Cycles render engine can be selected at the top of the Blender 3D View, where it currently says 'Blender Render'. Cycles is a physically based 'path tracing' renderer and as such can be slow, especially for interior scenes where there is a lot of indirect lighting, but it does eventually produce very realistic renders of the scene. A modern Nvidia graphics card can be used to significantly speed-up rendering with Cycles.

Upon selecting Cycles the results colouration will disappear from the 3D view. If the result colours are desired within the final render then some alterations to the 'calcsurf' material are required. Going back to the materials tab, with the cube selected, will now show a different materials panel specific to the Cycles Rendering engine. If the material has not been previously des-

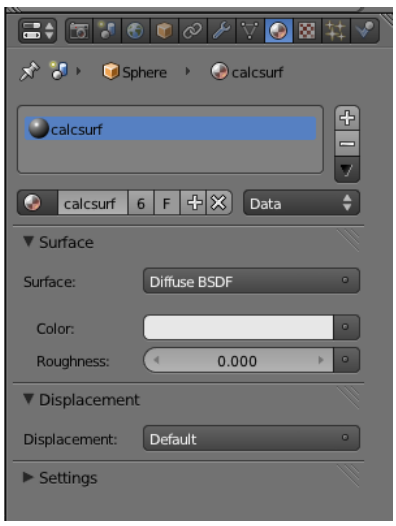

Figure 6: Cycles material panel

ignated as a Cycles material then the ’Use nodes’ button within the ’Surface’ section should be clicked. The material panel should now look something like figure 6.

On the right of the colour chooser is a small button. Click on this button and select ’Attribute’ from the ’Input’ section of the menu that pops up. This menu will then close. If a static simulation has been carried out type ’0’ (zero) in the ’Name’ box of the attribute. If a dynamic simulation has been carried out just press the left arrow key. This should register the correct attribute name for each frame of the animation.

In the ’World’ properties panel again select ’Use nodes’ if it is not selected and select sky texture from the menu that pops up when pressing the button to the right of the colour chooser. With the sun in the scene selected the ’Lamp’ properties panel becomes available. Go here to control the strength of the sun. Again pressing ’Use nodes’ may be necessary.

The 3D view can now be interactively rendered by selecting ’Rendered’ from the ’Viewport’ shading menu at the bottom of the 3D view, which is to the right of the ’Object mode’ menu. In the ’Render’ panel the view from the camera can be rendered out to an image, the type and location of which is defined in the output section of the ’Render Panel’.

Known Issues

The slightly modified version of Blender for Mac OS X, which is distributed with LiVi, can animate up to 250 frames of results. If using an unaltered Blender 2.62 release, as is released with the Windows version of LiVi, then only up to 8 frames can be animated. Going above these respective limits is likely to crash LiVi.