Accurate Light Intensity & Camera Exposure

One of the benefits when working with a physically based render engine is that we can rely on real world values for our materials, lights and camera settings. This gives us a tremendous advantage as we don’t have to work with arbitrary values and can take out most of the guess work.

By default Thea camera exposure is adjusted for exterior day light and this can give unexpected results when the user is not familiar with photography and tries to make interior renders with artificial lights. Even the artificial lights used have accurate light power (for example 100 watts light), the render comes out too dark. The immediate reaction is to increase the light power a lot to see some light but by doing this we actually interfering negatively in the physically based equation as we are introducing unrealistic values.

In general it is not a good idea to increase the light source power in an arbitrate way (specially when increasing the light source too extremes) as this will have negative effect on photo realism and can even produce more noise and take longer to clear the render (Thea has smart algorithms to deal efficiently with this situations).

Increasing the light power (including sky and sun light) was the work-flow of most render engines before physically based renders appeared on the market. There where no real light power values or camera exposure settings and one had to eyeball the final result. With physically based render engines the work-flow changes as all values are based on real world counterparts. When it comes to “taking the picture” we have to think about Thea like a real digital camera as this is what Thea is based on.

Instead of increasing the light power one has to take the camera exposure into account for a given light source. Day light is a huge magnitude stronger then a 100 watts light bulb and as the default camera exposure is set for daylight, one has to change the camera exposure setting accordingly for a much weaker 100 watts light source. An average exposure setting for interiors with artificial light is ISO 400, shutter speed 30 and F-Stop of 2.8. with this settings you will see the 100 watts light bulb illuminate the scene (image 01).

Image 01.

by default Thea exposure settings inside the darkroom and interactive display are set for exterior scenes. For interior scenes with artificial light a exposure settings like ISO = 400, Shutter speed = 30 and f number = 2.8 is an apropriate starting point.
There is another situation where we can get a too dark render even we have set our camera exposure correct and use accurate light source values. Most probable the problem will be that the scene was not build at real world size and instead of a 4×3 meter room, we are trying to illuminate with a single 100 watt light bulb a 40×30 meter room. Its clear that a single 100 watts light can not illuminate such a big room.

If the users has experience with photography he will feel at home with Thea as all photographic techniques can be used with Thea and will give the expected results. Thea captures the scene like a digital camera would do, so all knowledge of photography will benefit to get better and more photo realistic images.

Its important to think about Thea being a camera and not a human eye as this again can lead to confusion and unexpected results. A good example is an interior scene lit by sun/sky where we want to have the interior and exterior seen through a window exposed evenly like we see it with our eyes. This is not possible with a camera. One has to decide for which part of the image he is going to make the exposure, for the interior or the exterior seen though a window. Both can not get exposed correctly at the same time by a camera (image 02).

Photographers face the same problem and came up with different solutions which we can also use with Thea. The most common solution is to use extra lights to illuminate the interior. The goal is to make the interior light and exterior light have a similar intensity so one can get a good exposure for both.

We can make use of Thea relight capability which allows use to adjust the light intensity, color and contribution during rendering and even after we finish the render. A good idea is to save you image as Thea.img as this will allow you to open the image again inside Thea darkroom and you will be able to make adjustments to the exposure or even resume the render including relight (image 03).
Accurate light intensity & Camera exposure

Another “popular” solution is to wait until sunset and take the photos just when the sun is under the horizon and turned on all lights inside the room. The resulting image will have a nicely exposed interior with an exterior that looks like a day shot. With Thea we can simulate this by using a sunset HDRI for the environment light (IBL) and adjusting its intensity (image 04).

Image 03.
One of the “old work flows” make use of emitters on the windows which are set to be invisible to the camera and don’t cast shadows. The emitters are placed just behind the window glass so the light don’t has to pass through the window glass and we speedup rendering. The light power for the emitters is set to 1000,00 watts with a black-body temperature of the sky 6774K. We group all emitters and make use of Thea relight feature.

We use an exposure for the interior: ISO=400, shutter speed=150, f number=5,6

With relight we will have 3 light layers, one for the sun, another for the sky and the third one our emitters. Now we can adjust the light power and color of each light layer and achieve a render where the exterior and interior have a nice exposure.

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Image 04.
Making use of a sunset HDRI with low intensity values (the intensity value will depend on the HDRI used), we can use the following exposure settings for interior with artificial lights: ISO=400, shutter speed=30, f number= 2,8.
Apart from using those techniques, all images go through post processing which is and has been an essential part of photography since its beginning. Here we have an advantage over average digital cameras as Thea renders in 32 bit HDRI format which means that there is much more information stored than what get displayed at normal 8 bit image. It is possible to get details back from a burnout exterior making post processing on the original HDRI Thea image (image 05).

There exist an old “trick” which is to use a high gamma value and then add contrast and saturation to it. Some render engines do this by default as they are more focused on making renders that looks closer to how our eyes see reality. This of course alters the way light flows inside the scene and is no longer physically correct. This effect can give interesting results and is very popular as the final image has this “Magazine white walls” look (image 06). Its better to make this kind of post pro in Photoshop and not inside Thea as you will have more control over contrast, saturation and brightness.
CRF stands for Camera Response Function and is part of how a camera/film processes the final image. Cameras from different brands will produce different looking images. Most of the time the difference are very little in contrast, sharpness and saturation but with chemical film the difference can be quite big in final look. One could argue that this belongs to post processing but in fact its part of how a camera works and so should be taken into account when rendering (image 07).

![Image 07.
both images use ISO = 400, shutter speed = 150 and f number = 5,6. left image uses CRF = Agfacolor optima II 200CD and the image on the right a CRF = Agfacolor vista 800CD.](image)

Lets have a closer look on how the camera exposure settings work.

**ISO**

The main setting to affect exposure is the ISO value. The letters ISO stands for International Standards Organization and is followed by a number. This numbers are 50, 100, 200, 400, 800, 1600 (there are also some special films with ISO 64, 125 and 1000). The number indicates how sensitive the film is, meaning that a ISO 100 is 2 times more sensitive then a ISO 50 film. As you see each ISO number is always twice as sensitive then its precedent. Now days you will rarely find any chemical films but the ISO values have been adapted to modern digital cameras and have the same functionality for exposure. With digital cameras the ISO number can go up as high as 3200 and 6400.

When working with film, the ISO number has also an implication with the final image quality as lower ISO values had finer grain and so also more resolution. Higher ISO values had bigger grain which could be visible on the final image. With digital cameras there exist a similar issue, using higher ISO values can produce more grainy images specially when shooting with low light. *This don't happen when rendering with Thea. We don't get more noise when increasing the ISO value.*

The ISO values is the only value that only affects the exposure as shutter speed and f-number also affect exposure, they have other visual effects on the final image like Depth of Field and Motion Blur. One thing to note here is that f-number and shutter speed inside the darkroom or interactive display settings only have an effect on exposure and not on DoF or motion blur. To control Depth of Field and Motion blur, one has to use the camera settings at the camera properties panel. This “separation” has been made to give more artistic freedom and a better workflow as we don’t have to deal with
exposure and depth of field/motion blur at the same time which can become very restrictive.

The most important thing to keep in mind is that ISO 100 requires twice the exposure of ISO 200 and ISO 200 requires twice the exposure of ISO 400 and so forth.

Shutter Speed

The “shutter” of a camera can be imagined like the blinds of a window (being the window our camera lens). The shutter speed is how fast we can open and close the blinds to let a quantity of light get in. the faster we open and close the blinds, less light can come in and the more slow we open and close the blinds, more light can come in. this is another mechanism to control how much light will reach the film/sensor.

The shutter speed values are given in fractions of a second and common values are 1/1000, 1/500, 1/250, 1/125, 1/60, 1/30, 1/15, 1/8, ¼, ½ and 1. we can also give longer shutter speed values by entering floating point values. 8 seconds would be 1/8 = 0,125.

looking at the shutter speed values we can see that each time we reduce the shutter speed, we are increasing the amount of light that will reach the film/sensor by 2.

the shutter speed in the camera properties panel will also have an effect on motion blur but this will be explained in detail in different tutorial.

The most important thing to keep in mind for the shutter speed inside the darkroom and interactive display is that reducing the shutter speed, we increase the amount of light in our render.

F Number

cameras use normally the following f numbers 1, 1,4, 2, 2,8, 4, 5,6, 8, 11, 16, 22. Apart form this numbers, Thea also has a Pinhole mode which can be very useful when no depth of field is desired on the final render.

The f number can be seen as the size of our window where the light comes through. The bigger the window is more light can come through and the smaller the window, less light will come through. This numbers are probably the most confusing at first as they seem to not be very intuitive. The smallest number means the biggest “window” and the highest number, the smallest “window”. This means that an f number = 1,4 will let in much more light then an f number = 16.

if we look at the f number from the smallest to the highest we can see that each f number will halve the amount of light that can get to the film/sensor.

The f number in the camera properties panel will also have an effect on depth of field but this will be explained in detail in different tutorial.
Correct Exposure

when working with chemical film cameras, the only way to adjust the exposure was through shutter speed and f number as the ISO was fixed by the film that was being used. Now days with digital cameras the ISO can also be used for adjusting the exposure but as high ISO numbers can produce noise/grain, the shutter speed and f numbers are still the main exposure settings. With rendering we are not restricted and can use ISO alone to adjust the exposure as we will not get more noise when increasing this value. But if we are after photo real images we should use the settings a real camera would use.

ISO, shutter speed and f number gives us a flexible system to expose our scene correctly. We can create combinations of settings that will give the same exposure, this will be useful ones we take depth of field and motion blur into account.

For example lets say we get a good exposure with the following settings:

ISO = 100  
Shutter speed = 250  
f number = 5,6

we will get the same exposure with this settings

ISO = 100  
Shutter speed = 500  
f number = 4

we have doubled the shutter speed so less light will reach the film/sensor and to compensate for that we reduce the f number 1 step from 5,6 to 4 letting more light in.

if we increase the ISO but still want to keep the same exposure, we have to increase the f number or increase the shutter speed.

ISO = 200  
Shutter speed = 500  
f number = 5,6

all three examples will give the exact same exposure but if we also use the same settings in the camera properties panel, we will get different kind of depth of field and motion blur.

Correct light intensity

As mentioned in the beginning of this tutorial, its not recommended to use arbitrary extreme light intensity as this can have a negative effect on achieving photo-real images and can even lead to longer render times and more noise.

With physically based render engines we use accurate light values like Watts, Lumen, Candelas, lm/m² or cd/m^2 to mention some of the available light power unities one can select with Thea.

Light intensity data can be found at light manufacture web pages or on the packaging box of light bulbs. Using this data will give the correct light intensity for rendering with Thea.
Watts
This is one of the common light units used to assign the power of a light source. It also comes with a second unit called efficacy which indicates how much energy is converted efficiently to light. A common incandescent 100 watt light bulb used to have an efficacy of around 17. Another light bulb rated at 100 watts but with an efficacy of 20 would emit more light even having the same wattage as it efficiently can return more light then the one with efficacy 17.

Lumen
Is another light power unite that is often used by light bulb manufactures. Lm is a SI (international system of units) for luminous flux.

Lum/m^2
This unite defines 1 lumen per square meter. Use this unite when you want to change the light power of your mesh emitter depending on its size.

By default using watts or lumen on a mesh emitter, the light power get distribute uniformly across the surface. This can lead to confusion because when changing the size of the emitter, the light power dos not change but it apparently get dimmer the bigger you make the emitter. This situation is appropriate when simulation soft-boxes used by photographers as it mimics the light spreading/dimming of the soft box surface (image 08).

But this is not always a desired effect and sometimes we want the mesh emitter change its power strength according to its size. In this case using lum/m^2 is the light unit to use (image 09).
I hope this tutorial can help producing better and more photo real renders. Using real world values for lights, materials and exposure will bring your renders a step closer to photo realism. The temptation to manually alter light intensity including the sun is always there as many tutorials from other render engines make use of it. But Thea belongs to a different kind of renders where this work-flow belongs to the past. Understanding this is the first step in improving your renders with Thea. Does this mean that one can not alter the sun power to get a different result? Of course not but understanding that Thea is based on real physics can help to do things in a better way. For example instead of altering the sun power we can increase the sun radius and this way get a much more realistic result of an over caste sky or better make use of a HDRI. If we look at our renders from a photographer point of view we will be much more successful using photographic techniques.

The next time your lights come out too dark, you know now that you just have to change the exposure settings and you can do this even during rendering.