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Antti Kämä

PHOTOREALISTIC LIGHTING AND RENDERING OF A SMALL APARTMENT INTERIOR

– A case study with 3DS Max and V-Ray

TURUN AMMATTIKORKEAKOULU
TURKU UNIVERSITY OF APPLIED SCIENCES

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Principal Lecturer Mika Luimula, Adj.Prof.

Antti Kämä

PHOTOREALISTIC LIGHTING AND RENDERING OF A SMALL APARTMENT INTERIOR

- A case study with 3DS Max and V-Ray

The purpose of this thesis was to examine the process of creating photorealistic lighting for a small apartment interior and the process of rendering that interior. Both nighttime and daytime lighting was created for the 3D interior scene modeled beforehand. The 3D interior scene was comprised the walls, windows and the largest furniture of the apartment excluding the bathroom.

The theoretical section of the thesis focuses on different settings and features which in combination influence the photorealism of the final render result. These settings and features include the difference between natural and artificial light sources, the shadows created by these lights, Global illumination settings with Brute Force and Light Cache engines and shaders determining the light’s behavior on the surface. Finally, the basic camera settings and their influence on render result were examined.

In the empirical section of this thesis, the geometrical features of 3D models and their influence on shaders and lighting were briefly examined. After that, the creation of daytime lighting with natural simulated light and the creation of nighttime lighting by using artificial photometric lights was implemented. Next, the basic shaders for the scene objects were designed and applied and the camera settings adjusted for both daytime and nighttime scenes. Finally, the rendering and Global Illumination settings were briefly discussed and applied and the final images rendered.

3D Studio Max was chosen as a modeling software because of the earlier knowledge and the user experience of the software and the free student license available. V-Ray was chosen for rendering software because of its fairly low price for non-commercial educational use and its popularity among photorealistic design and architecture.

The final results of this project were high-quality, nearly photorealistic rendered images of the room interior suitable for a portfolio. However, additional adjustments on metal and fabric shaders would have increased the photorealism even more and the rendering optimization would have led to shorter rendering times.

KEYWORDS:

3D-modeling, rendering, photorealism, lighting, V-Ray, 3D Studio Max

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Antti Kämä

PIENEN ASUNNON SISÄTILOJEN FOTOREALISTINEN VALAISU JA KUVANTAMINEN

- Case 3DS Max ja V-Ray

Opinnäytetyön tavoitteena oli tutkia pienen huoneiston sisätilojen fotorealistisen valaistuksen luomista ja näiden valaistujen sisätilojen kuvantamista. Ennalta mallinnetulle 3D-sisätilaympäristölle luotiin päivä- ja yövalaistus. 3D-sisätilaympäristö koostui seinistä, ikkunoista ja suurimmista huonekaluista pois lukien kylpyhuone.

Teoriaosuus keskittyi eri asetuksiin ja ominaisuuksiin, jotka yhdessä vaikuttavat lopullisen kuvantamistuloksen fotorealistisuuteen. Nämä asetukset ja ominaisuudet sisältävät eroavaisuudet luonnonvalon ja keinotekoisen valon välillä, valaistuksen tuottamat varjot, heijastusasetukset Brute force ja Light cache –moottoreilla sekä asetukset valon käyttäytymiseen objektien pinnalla. Lopuksi tutkittiin kameran perusasetuksia ja niiden vaikutusta kuvantamistulokseen.

Käytännön osuus tutki yleiseti 3D-mallien geometrisiä ominaisuuksia ja niiden vaikutusta valaistukseen sekä valon käyttäytymiseen objektien pinnalla. Tämän jälkeen tehtiin päivävalaistus simuloidun luonnonvalon ja yövalaistus keinotekoisten valojen avulla. Seuraavaksi suunniteltiin ja asetettiin objekteille perusasetukset valon käyttäytymiseen niiden pinnalla sekä säädettiin kamera-asetukset yö- ja päivävalaistukselle. Lopuksi pohdittiin lyhyesti kuvantamis- ja heijastusasetuksista, jotka säädettiin sopiviksi, minkä jälkeen lopulliset kuvat kuvannettiin.

3D Studio Max valittiin mallinnusohjelmistoksi siihen aiemmin hankitun tiedon ja käyttökokemuksen sekä ilmaisen opiskelijalisenssin vuoksi. V-Ray valittiin kuvantamisohjelmistoksi sen suhteellisen edullisen, ei-kaupalliseen tarkoitukseen tarkoitetun opiskelijalisenssin sekä sen fotorealistisen suunnittelun ja arkkitehtuurin keskuudessa vallitsevan suosion vuoksi.

Projektin lopputuloksena on portfolioon sopivat korkealaatuiset, lähes fotorealistiset, kuvannetut kuvat huoneiston sisätiloista. Fotorealistisuuden lisäämiseksi projekti vaatisi kuitenkin säätöjä valon käyttäytymiseen metallisten ja kankaisten pintojen pinnalla. Lisäksi kuvantamisen optimointi olisi johtanut lyhyempiin kuvantamisaikoihin.

ASIASANAT:

3D-mallinnus, kuvantaminen, fotorealismi, valaistus, V-Ray, 3D Studio Max

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LIST OF ABBREVIATIONS

Natural light	Light supplied by the sun (LoveToKnow Corp. 2016). In 3D lighting known as simulated natural light.
Dominant light	Light with the strongest intensity in a scene (Brooker 2006, 22).

1 INTRODUCTION

Photorealistic lighting and rendering is a process where three-dimensional, computer generated scene is lighted so that the rendered image of the scene resembles as much as possible an actual image taken with a real camera. The thesis goes through the significant areas of photorealistic lighting and rendering and how they are used to reach the most photorealistic lighting for interior of one-room flat.

The writing and the practical sections of the thesis are being guided by Ville Riikonen, the CEO of Voima Graphics Ltd. Voima Graphics is a Helsinki-based 3D graphics production studio, specialized in photorealistic architectural modeling and rendering.

In this thesis, the theoretical section investigates photorealistic lighting and rendering from non-software-specific point of view, meaning that these aspects can be applied in any modeling software. However, in the practical section the 3D Studio Max modeling software and the V-Ray rendering software are being specifically used.

The first theoretical section of the thesis defines the meaning and purpose of rendering and photorealism. The second section determines the difference between natural and artificial light sources and how they are used in lighting process. The section discusses the purpose of shadows and finally defines the importance of global illumination and its two major engines for photorealistic rendering found in V-Ray: Light cache and Brute force. The third section discusses the importance of shaders of the scene objects and defines the most significant shader parameters: diffuse, glossy and specular reflections with the addition of refraction. The last part investigates the camera settings and how these influence to the rendered image.

In the practical section a photorealistic lighting for interior of one-room flat is being created as a high quality project using an actual flat as a reference. The modeling process is being discussed briefly and its most significant features to photorealistic results are being stated. Next, the daytime and nighttime lighting are being created to light the scene and shaders will be assigned to the scene objects. In the final section the camera and rendering settings are being discussed and adjusted to be suitable for the scene and the final images of the room with the daytime and the nighttime lighting will be rendered.

2 PHOTOREALISTIC LIGHTING AND RENDERING

2.1 Rendering and photorealism

Rendering, in the context of 3D graphics, is a process in which two-dimensional image is being translated from imaginary, mathematical approximation of a three-dimensional scene. In the rendering process the optional simulations mimicking reality, such as light, shadow, textures and different optical illusions are being processed and applied to the final image. (Birn 2002; Slick 2014a.)

The most used rendering technique to achieve high quality results is raytracing, because it "simulates natural reflection, refraction, and shadowing of light by 3D surfaces" (Birn 2014, 330). In raytracing rendering process, rays are being traced from the camera to the scene in order to determine the area of the final image. From each point of the determined area, rays area being traced to the light sources of the scene in order to create shadows and direct illumination; if the ray reaches the light source, the point in the final image will be lighted with direct illumination but if the path of the ray is being blocked by the object, the shadow is created to the final image. (Chaos Software Ltd. 2016a.)

3D photorealism can be simply defined as ”images that can be mistaken for a photograph” (Birn 2014, 10). The 3D photorealism is probably most familiar from visual effects of films and tv-shows, in which the 3D photorealism is used to create scenes and characters which would be impossible or too dangerous to carry out in real life.

However, the 3D photorealism is also used in architectural visualization because it provides a better perspective of final structure to customers and improves the development process. Additionally, it provides designers and architects a possibility of visualizing their ideas in more creative and realistic ways. (Stowe 2013.)

2.2 The beginning of the lighting process

When designing and creating a photorealistic interior scene for rendering, the lighting is one of the most crucial aspects of the process. Without any lights in the scene, the rendered image would appear entirely black and would therefore be useless. Each light of the scene have their own origins (or motivation) which determines the qualities (colour temperature, brightness etc.) of the light (Birn 2014, 2-4).

Before the lighting process of the interior scene starts, it is highly important that the scene layout is ready and the position of the camera and the time of the day have been determined (Birn 2014, 21). Although the image rendered through the camera might not show the entire scene, it is important that the scene layout is finished, because of the off-screen space.

Off-screen space is an area which is not visible in the rendered image, for example the area behind and above the camera. Although the area is not visible to the camera, it probably has influence on the lighting of the shot; the light sources might be outside the shot illuminating light to the visible area or the off-screen space might include objects which create shadows or reflections to the final rendered image. (Birn 2014, 2.)

2.3 Features of light

2.3.1 Natural and artificial light sources

When starting the lighting process of a room interior, the outline of the room and the time of the day should already be determined. That is because of the influences of natural light and artificial light on the scene. In 3D lighting natural light refers to the light emitting from the sun or illuminating from the sky and artificial (also known as practical) light refers to the light emitting from models representing human made objects, for example lamps, televisions and such (Birn 2014, 111,138).

When the interior 3D scene has relatively large windows, as there usually are for example in living apartments, the dominant light in daytime scene is natural light emitting through the window. In contrast, the nighttime scene, when there is no natural light emitting through windows, lighting is created through practical lights. This difference in the influence of a practical and a natural light during the different times of day can be seen in picture 1.

Picture 1.A room interior scene lighted with daytime (left) and nighttime (right) lighting (Mintviz.com 2013)

As it can be seen in the left image of picture 1, the scene is very bright because of the natural light emitting from the sun through the roof windows. In contrast, the right image of picture 1 is lighted with practical lights creating much dimmer scene. The difference in the colours of the light can be noticed between the pictures; the sunlight coming through windows seems to be much whiter while the artificial light seems more yellowish.

2.3.2 Colour temperature

The colour difference of the light is caused by the scientific term called a color temperature; temperature (measured in Kelvin) in which a block of carbon produces a light with specific colour. Table 1 shows the colour temperatures of different objects in Kelvins and their approximate colors with indoor and outdoor colour balances.

Light source	Colour temperature in Kelvins	Colour with indoor (3200K) colour balance
Match Flame	1 800	
Sunrise/sunset	2 000 - 3 000	
Household tungsten bulb	2 500-2 900	
Sun: Direct at noon	5 000 - 6 500	
Sky: Overcast	6 000 - 7 500	
Sky: Partly Cloudy	8 000 - 10 000	

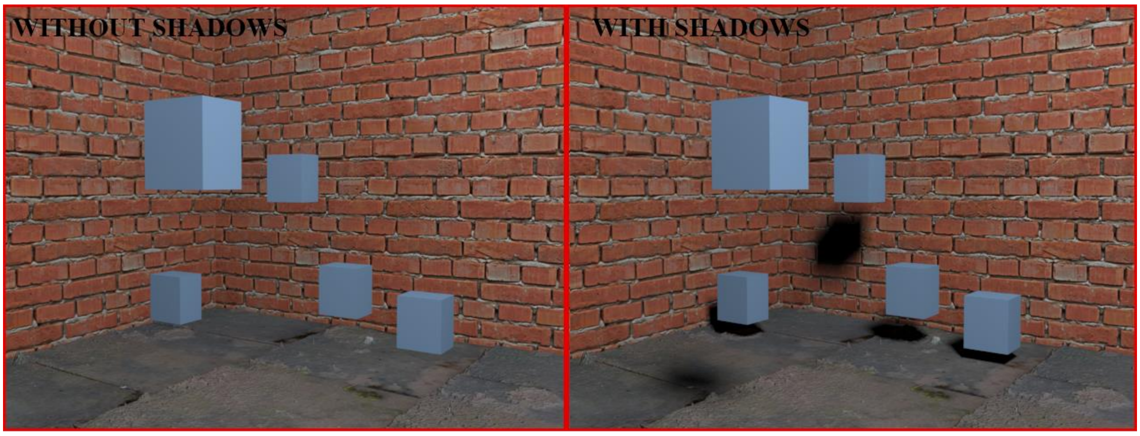
Table 1. The colours and colour temperatures of different light sources. (3Drender.com 2001)

Based on the information in table 1, it can be defined that the artificial lights used in nighttime scene of picture 1 include household tungsten lamps because of their yellowish color which addresses the colour temperature between 2500 and 2900 Kelvins. Based on the daytime scene of picture 1 the natural light seems to be direct sunlight at noon, setting the color temperature between 5500 and 6500 Kelvins.

The color temperatures of the lights influence also to the mood of the scene, due to the human tendency to “describe red, orange, and yellow as warm colors, as opposed to blue and green, which are cool colors” (Birn 2014, 288).

2.3.3 Shadows

Shadows have, alongside lights, a major part in photorealistic lighting especially because of their role in defining spatial relationships between objects. From a shadow of an object, the viewer perceive “what an object is made of, how far away it is and how it relates spatially to its surroudings” (Brooker 2006, 43). Shadows’ influence on determining spatial relationships can be seen in picture 2.



Picture 2. Identical scenes lighted without and with shadows.

From the image without the shadows in picture 2, it is very difficult to determine the position of the blue boxes; whether they are attached to the wall or the concrete or not. Also, determining the size of the boxes relative to each other can be difficult; for example the largest box in the image without shadows is, as the shadows in the other image reveals, closer to the camera and is actually identical in size to the other boxes.

Additionally, the shadows identify the direction from which the light is illuminating. For example, from the shadows in picture 2, it can be roughly determined that the light comes from top and right (outside the image), because the shadows are located below and on the left of the boxes causing the shadows. Futhermore, from the shadows it may be possible to determine the distance and luminosity of light; closer the light source is to the object, the larger is the shadow. In contrast, as the light is moved futher away from the object, the shadow relatively grows smaller to the size of the object itself (Birn 2004, 63). Additionally, the smaller the light source is compared to the object, more hard-edged and more contrasted the shadows are and will soften as the light source is enlarged. (Curtin 2011).

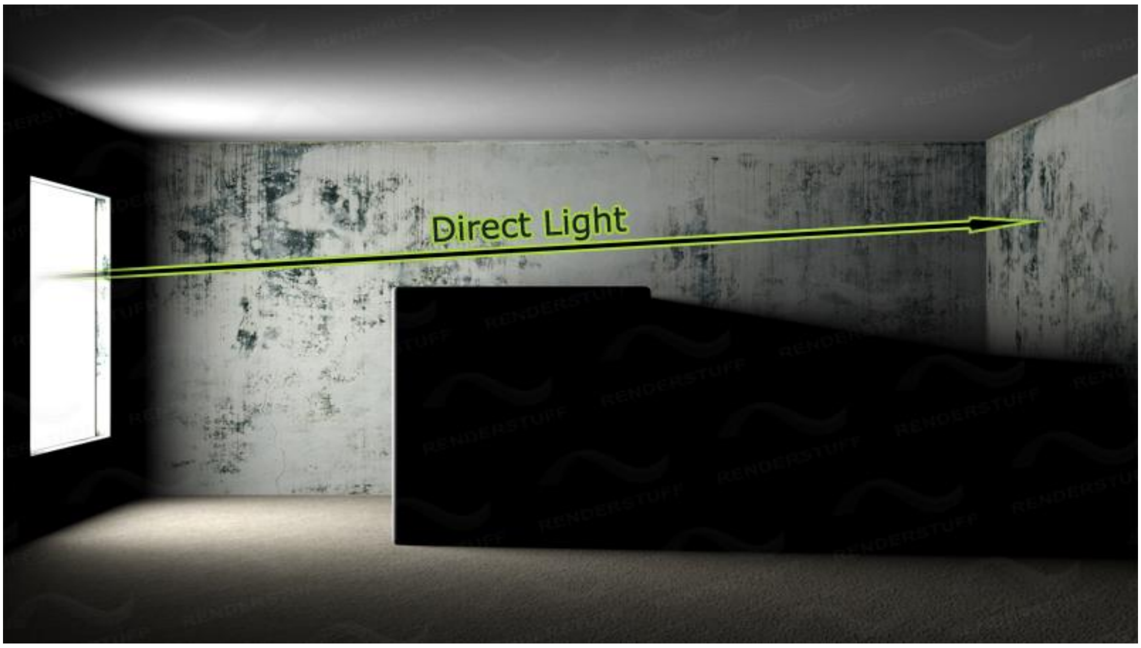
In interior lighting, shadows can be used to reveal the off-screen space outside the camera's view; the objects outside the view might cast shadows on the surface of the final image (Birn 2014, 59). A shadow casted by an object on the off-screen space can be seen in picture 3.

Picture 3. Throw pattern of sunlight on the surface of the shelf caused by Venetian blinds.

From the shadow in picture 3, it can be determined that there are venetian blinds used although the blinds or the window are not visible in the picture itself and therefore are located in off-screen space.

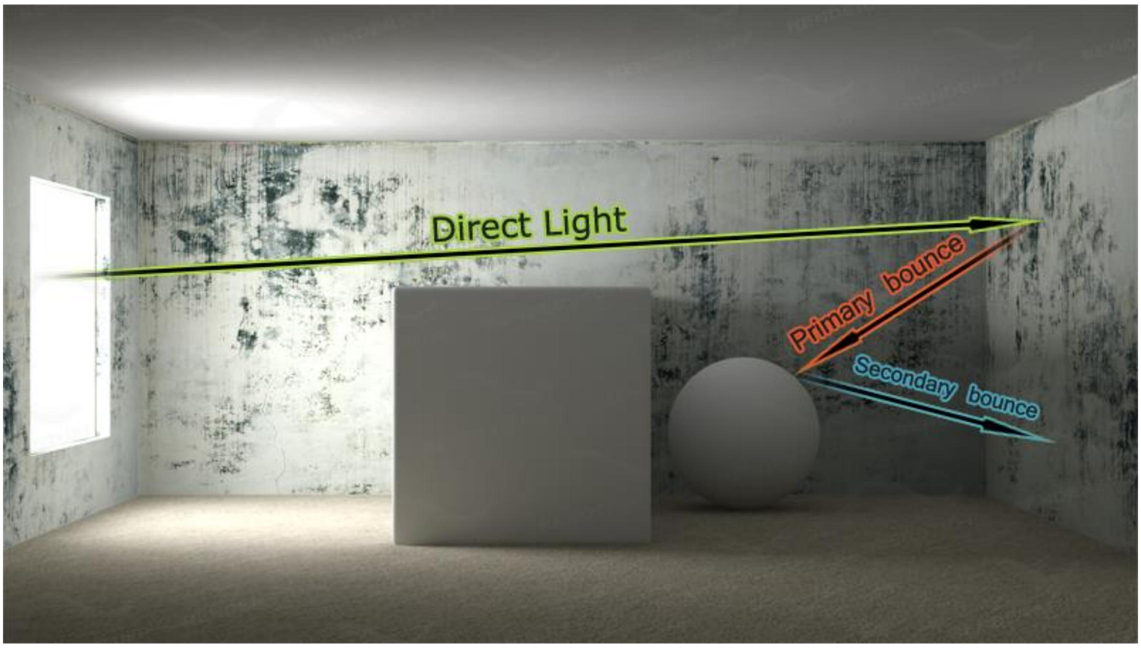
2.4 Global Illumination –methods

Global illumination, also known as indirect illumination, is one of the rendering algorithms which, unlike local illumination algorithm, calculates the indirect illumination bouncing back from the surfaces (Birn 2014, 343). Pictures 4 and 5 show the influence of global illumination.



Picture 4. An interior scene lighted with one directional light illuminating through window when global illumination is disabled. (Renderstuff.com 2013)

In picture 4, where global illumination is disabled, it can be seen that the space behind the box is very dark, because the box blocks the direct illumination from the window and creates very strong shadow behind it. However, in real life the direct light would bounce back from the white wall and enlighten the area behind the box. Once the global illumination is enabled, the rendering algorithm calculates the angle in which the direct light hits the wall and calculates the angle and intensity of the light bouncing back from the wall. This effect can be seen in picture 5. (Renderstuff.com 2013.)



Picture 5. Interior scene lighted with one directional light illuminating through window when global illumination is enabled. The angles of reflection are not in scale. (Renderstuff.com 2013)

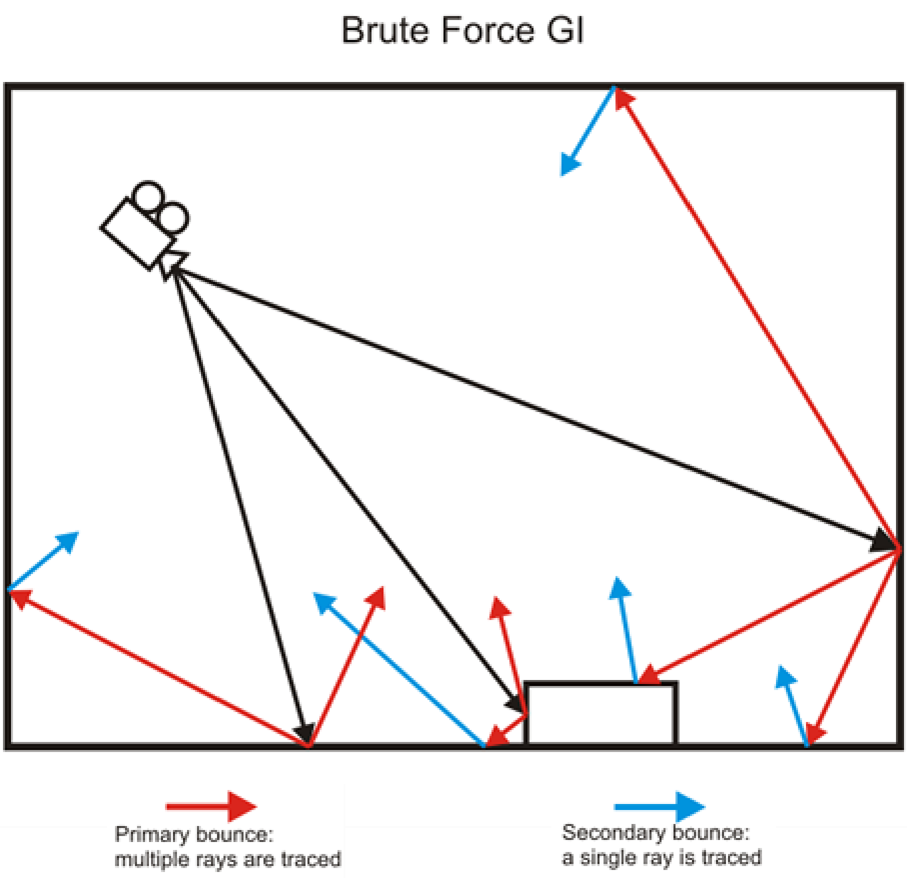
The picture 5 shows how the light bounces from the wall and the ball, which was not even visible when global illumination was disabled, lighting up the area behind the box. As seen in picture 5, the reflecting lights are called bounces and all other light in the scene is commonly called indirect light, except the one illuminating directly from the source. (Renderstuff.com 2013.)

Global illumination has a major influence on interior lighting as a one feature of a light and as Birn states in his book, it is “the easiest and most realistic way to render indirect light indoors” (Birn 2014, 129).

There are different ways to compute the indirect illumination depending on the rendering software used. However, when targeting for photorealistic results with V-Ray, the Brute force is mainly used as primary engine to calculate primary bounches and the Light cache is used to calculate secondary bounches of light. This combination produces images with very good quality and is suitable for high quality interiors (Aversis3D 2016). These two engines are discussed in next sections in more detail.

2.4.1 Brute Force

When the Brute Force is selected as a primary engine in V-Ray, it determines the primary bounces by tracing the rays of direct light from the camera to the scene as picture 6 shows (Chaos Software Ltd. 2016b).



Picture 6. Rays being traced when The Brute Force is primary and secondary engine. (Chaos Software Ltd. 2016b)

In the picture 6, it can be seen how the primary bounces (red) are traced when the Brute force is selected as a primary engine. Because of the fact that the rays are traced from the camera, makes the Brute Force a view dependent leading to more accurate results. (Chaos Software Ltd. 2016b). In other words, the movement of the camera inside the scene does not affect to the global illumination in the final render. In contrast, for example photon map traces particles from the light source, which might lead into different kind of global illumination results when the camera is moved from one point to another (Chaos Software Ltd. 2016c).

Additionally, in the Brute Force's GI settings, it is possible to increase the quality of GI by increasing the number of subdivisions, which is propotional to the total number of rays which are being traced by V-Ray (Chaos Software Ltd. 2016b). As a result, the rendering time is increased, but when aiming for photorealistic results, the quality is preferred over the rendering time.

2.4.2 Light Cache

The Light Cache as a secondary engine is used to spread light around the scene while the Brute Force as a primary bounce calculator processes the details of the scene (Mintviz 2011, Rebulic of Code 2010).

Once the Brute force's primary rays have bounced the amount they are supposed to, the rays change into Light Cache rays which store the illumination into a 3D stucture. If this ray hits a point which is already processed by Brute Force's ray, the tracing ends and the information already available is read and thus speeds up the rendering process. As a secondary GI engine, Light Cache processes soft and clean shadows and produces accurate results of corners and small objects to the final render. (Chaos Software Ltd. 2016d.)

2.5 Shaders

Shaders define how light responds to the surfaces of the object the shaders are applied to. In some software material –word might be used to represent shaders, but actually all adjustable settings influencing on surface appearance are shaders. (Birn 2014, 312.)

2.5.1 Diffuse, glossy and specular reflection

There are three most commonly used variables in shader settings and these three variables have also the major influence on the appearance of a surface. These variables are diffuce reflection, glossy reflection and specular reflection. These three variables appear in most of the surfaces and are caused by the different levels of roughness on the surface of the object. The influence of roughness can be seen in a microfacet model which “simulates the roughness or jaggedness of surfaces on a microscopic level” which is visible in figure 1. (Birn 2014, 312-315.)

Figure 1. Microfacet models expressing the lights behaviour in diffuse, glossy and specular reflection. (Birn 2014, 315)

In figure 1, it can be seen that the rougher the surface is on microscopic level, the more diffused it will be, because of the light scattering in every direction. In contrast, the smoother the surface is, the more perpendicularly the light is reflecting and the more specular it will be. Based on the illustration in figure 1, it can be said that glossy reflection is a phase between completely diffuse and completely specular materials. However, there are no fully diffuse or fully reflective materials in real life, so all the materials include some amount of glossiness (Birn 2014, 313). The materials with diffuse, glossy and specular reflections can be seen in picture 7.

Picture 7. Rendered teapots with diffuse, glossy and specular reflections.

In picture 7 it can be seen how diffuce reflection material (left) does not create any highlights while specular reflection material (right) creates a mirror like reflections reflecting the surrounding of the object. The glossy material (middle) on the other hand is intermediate between these two reflections and the rough shape of light source is reflected from the surface and the rought reflection of the teapot can be seen as a slightly brighter area on a plane below teapot.

2.5.2 Refraction

Refraction, the bending of light, occurs when light “passes from one transparent substance into another” (Science Learning 2012). The bending is caused by the change in speed of light in different substances, for example light travels faster in air than for example in glass (Gibbs 2013). An example of refraction can be seen in figure 2.

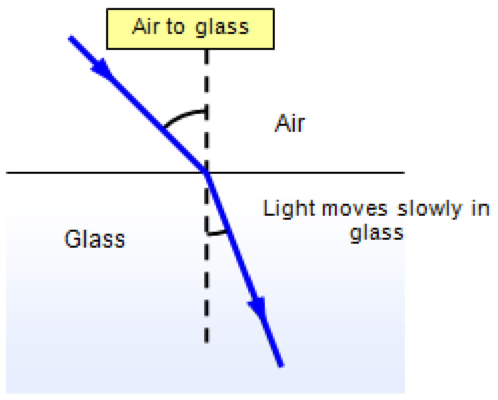


Figure 2. The bend of light when it travels from air to glass. (Gibbs 2013)

As a figure 2 shows, the light bends towards the normal line when the light moves to the substance where it travels with slower speed.

Refraction is important shader attribute in photorealistic rendering, especially when there are glass objects, for example glass bowls involved in the scene. The refraction attribute is relatively easy to apply on shaders because of the index of refraction –values, which are available for most of the transparent substances in internet and these values can be applied to the shaders (Reynolds, 2013) .

2.6 Camera settings

3D rendering software cameras aim to simulate the real world cameras, and therefore knowing how the real cameras work helps producing more realistic results in rendering process (Autodesk Inc. 2016a). The three important settings of the camera are the size of the aperture, the shutter speed and the ISO value of the camera, which together cause the exposure value determining how bright the final image will be (Birn 2014, 228).

The aperture is a hole in a lens, which allows the light to travel into the body of the camera. The larger is the size of the aperture, the more light reaches the camera and brighter the shot will be. The aperture is expressed as f-stops (for example f/2.8) and the numerical value is inversely propotional to the size of the aperture. In other words, the smaller is the value, the larger is the aperture. (Mansurov 2009.)

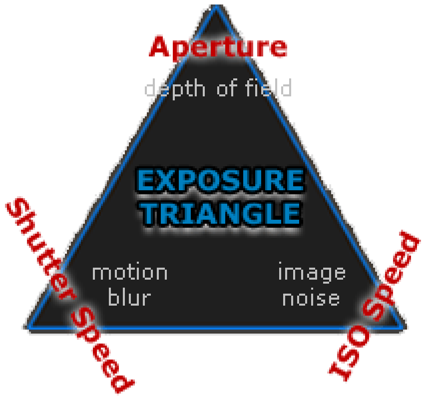
The size of the aperture has an inversely propotional influence to the depth of field, the smaller is the size of the aperture (larger the f-stops value), the larger is the depth of field. Depth of field refers to the distance which appears sharp in the photo. (Surmabojov 2011.) The influence of the size of the aperture on the depth of field can be seen in picture 10.

Picture 8. Influence of the size of the aperture on the depth of field with the shutter speed values given. (Boost Your Photography 2014)

In picture 8 the shutter speed values are also given. The shutter speed refers to the time the shutter of the camera is open and is expressed as a fraction of a second. In other words, it determines how long the camera records the photograph. Additionally, the longer the camera records the scene, the more light reaches the camera and the brighter the shot will be. (Cambridge in Colour 2016, Rowse 2016.) For example, for the shots in picture 8, the shutter speed has been decreases as the size of the aperture has been decreased so that the amount of light reaching the camera remains the same and therefore the brightness of the shots have been maintained equal.

ISO value refers to the light sensitivity of the camera. The larger the ISO value, the more sensitive the camera is to the light. For example, when taking a photograph in bright daylight, the exposure should be small and when taking shots with less light, for example at night, the exposure should be larger. However, the larger exposure values influence to the quality of the shot by making it noisy. (Peterson 2016.) Therefore, while photographing for example a night sky, the good balance between exposure and the shutter speed should be established in order to maintain good quality of the shot.

All these three previously mentioned camera settings influence to the exposure of the photograph which refers to how bright or dark the final photograph will be (Cambridge in Colour 2016). The picture 9 shows the relation of aperture, shutter speed and ISO value to the exposure of the photograph.



Picture 9. The relation of aperture, shutter speed and ISO value to each other and to the exposure. (Cambridge in Colour 2016b).

3 LIGHTING AND RENDERING A ROOM INTERIOR

3.1 3D Studio Max and V-Ray

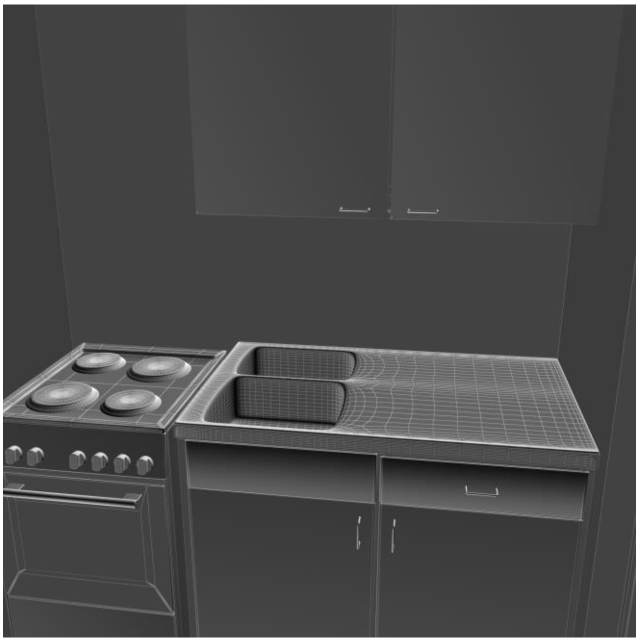
3D Studio Max (also known as 3DS Max) is a “3D modeling, animation, and rendering software” developed by Autodesk Incorporation (autodesk.com, 2015). 3S Max is one of the most used software for 3D architectural rendering because it helps creating “static or animated architectural rendering house models that sometimes look like real photograph”. One of the 3DS Max’s advantages is also its ability to work with other software such as Adobe Photoshop and After Effects to create even more realistic renders. (Goldman 3D Renderings, 2012.) The price of the software is 1600€ per year but for students there is free educational license available (autodeks.com, 2016b).

V-Ray is a rendering software developed by third-party developer, Chaos Software Ltd. It is one of the most used rendering software by architects and designers because of its large texture library and it is excellent for working with architects most influential tools, light and shadow (Secan 2016). V-Ray costs 300€ per year for one workstation but for students there is Academic license available for 74€ per year. (Chaos Software 2016e)

3.2 Modeling process

Modeling process of the room interior was done beforehand and therefore it is not thoroughly explained in this thesis. However, there are few points that should be clarified from the lighting’s point of view. These points are what is modeled and how they are modeled and their influence on lighting.

When beginning to start the modeling process, it was decided, because of the limited working time, that only the largest furniture will be included in the scene. The largest furniture refers to relatively large and in some cases immovable objects, for example closets, shelves, a couch and so on. These object have the major impact on lighting and once the scene lighting is ready, it is easy to create and adjust smaller objects to lighting of the scene. In the pictures 10 and 11 the modeled scene can be seen. The objects in the scene are measured to resemble the actual reference apartment with accuracy of ±0,5cm.



Picture 10. Modeled kitchen with standard edge material and scene lights, no shading applied on materials.

From picture 10 it can be seen that the objects are modeled to follow as good topology as possible. Topology refers to the way polygons “are connected together and the flow around 3D object” (Digital-Tutors 2013). Also the objects are created so that the polygons are quadrilaterals, meaning that the polygon is made of four edges connected by four vertices. If the polygons were N-gons or triangles, they could cause some issues and artifacts with light reflection in rendering process. (Mayden 2016, Masters 2015.) Additionally, the sharp edges of some objects in the scene are smoothed, because of the fact that “there are almost no razor sharp edges in nature” (Slick 2014b).

3.3 Creating the lighting for the scene

3.3.1 Creating a daytime lighting

At the beginning of the lighting process, it was planned to create the natural lighting with V-Ray’s domelight. Domelight is hemispherical dome that is placed above the scene and illuminates light to scene from all directions and is therefore excellent for simulating the light from the sky. (Birn 2014, 31, Chaos Software Ltd. 2016f.)

However, in this case the purpose is to create a lighting for interior scene, in which the natural light is illuminating through the windows that are placed on one side of the apartment. Therefore, the light illuminating to the sides of the apartment that are blocked by walls and therefore do not have influence on scene’s lighting would still be computed. The computing of these uninfluential lights might ”lead to very slow render times” (Birn 2014, 125).

As a result, the VRaySun and VRaySky are used to simulate natural light. This combination creates a sun light but also illuminates sky light, so that also the sky can be visible through the window. This light system differs from dome light so that the light is only emitted from the sun’s position, leading into situation in which all unneccessary light emission when using dome light is excluded. Also the light system is coded so that the sun’s vertical position affects to the sky’s illumination. For example, when sun is positioned near the ground level, the light emitted appears more yellowis and reddish as it does in real world when sun is setting down.

Picture 11 shows the rendered result of the living room with no changes made on the camera. There are no shaders used in picture 11 except on the windows in order to let the light travel through them and the global illumination is enabled.

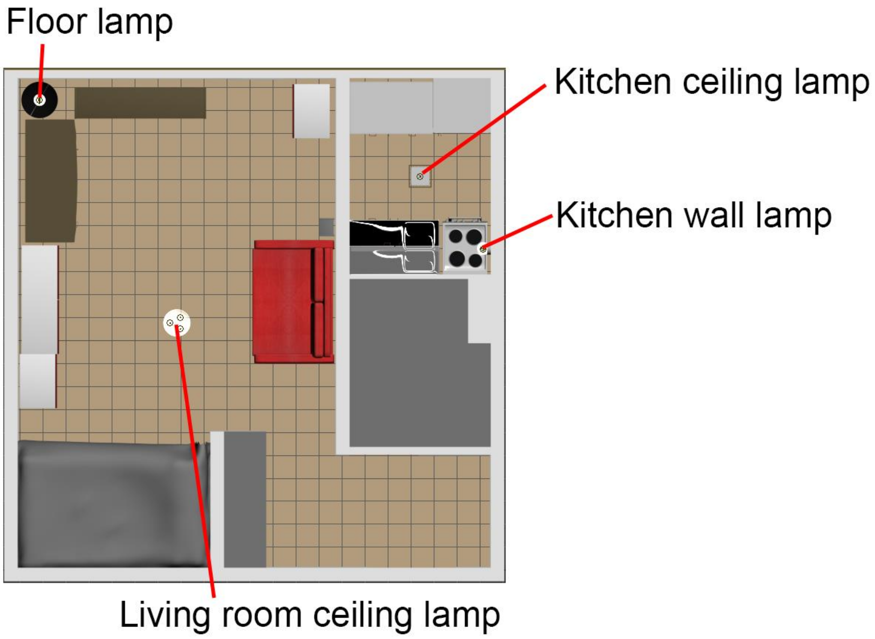
Picture 11. Living room rendered with sun and skysystem and without shaders except in the windows.

The picture 11 shows that the natural light look quite good and therefore it allows to start working with the shaders of the furniture. The possible changes to the light and camera settings will be done in later phase of the process.

3.3.2 Creating a nighttime lighting

For the night time scene, the photometric lighting is created by V-Ray's IES photometric lights. The word photometric refers to light's photometric values which allows the user to define accurate light properties to resemble the real world references. Additionally, like real world lights, photometric lights attenuate with inverse-square falloff which means that the light is very bright near the source but gets dimmer quickly as camera moves away from the source. Because of inverse-square falloff property of photometric light, it is crucial that the scene is modeled in real world units, for example inches or meters. (Autodesk Inc. 2016c, Epic Games Inc. 2016.)

For the night time scene, there are four different lamps used; a ceiling lamp in the living room, a floor lamp in the corner of the living room, a wall lamp and a ceiling lamp in the kitchen. Picture 12 shows the position of these lamps in the scene layout.



Picture 12. Named lamps in scene layout

For the lights in picture 12, the light bulb and type information was checked and their colour temperature (in Kelvins) and power (in lumens) was determined from the internet. These colour temperature and power values can be found from table 2.

Lamp	Bulb model	Colour temperature (K)	Power (lm)
Living room ceiling lamp	3 x Airam E27 42W/240V	2800	630
Floor lamp (adjustable)	Haloline SST 230W 240 V R7S	2950	5000 (adjustable)
Kitchen ceiling lamp	Airam 42W/240V	2800	630
Kitchen wall lamp	Airam 42W/240V	2800	630

Table 2. Lights used for nighttime scene lighting and their bulb models, colour temperatures and power. (Puuilo.fi 2016, osram.com 2016)

In picture 13, the living room can be seen lighted with practical lights and objects having default V-Ray shader except the lamp shades which have opaque glass shaders.

Picture 13. Living room lighted with practical lights, objects having default shaders and no adjustments done on the camera settings.

In picture 13, the luminosity between the floor lamp and ceiling lamp can be seen. However, the real world reference of the floor lamp has continues controller for the power. During the nighttime the floor lamp is mostly used with one fourth of the maximum power. Therefore, in order to stabilize the influence of the lights, the luminosity power of the floor lamp is adjusted to one fourth of the maximum power which equals 1250 lumens. In picture 14 the same scene can be seen with adjusted floor lamp power.

Picture 14. Living room lighted with practical lights and floor lamp luminosity power adjusted to 1250 lumens, objects having default shaders and no adjustments done on the camera settings.

In picture 14 the lamps seem to have more balanced influence on the scene when compared to picture 13. However, the scene appears still very dark which is result of the camera settings, which are still adjusted for rendering interior scene with daylight. The camera setting adjustments for nighttime rendering will be done in section 3.5.2.

3.4 Setting up the shaders

The shading process was started by applying diffuce colours which resemble the real world references as much as possible. At this point the light’s behaviour on the shader was excluded. In picture 15 the living room can be seen with only diffuse colours applied on them.

Picture 15. Living room lighted with sun and sky system and diffuse colors applied on objects.

When comparing picture 15 to picture 11 the major influence of diffuse colours to the brightess of the scene can be seen. The living room appears much brighter and clearer once the diffuse colours have been applied. However, there are objects that still require some shader adjustments. For example, the couch does not look like it is made of real fabric but more like red boxes. Also the wood material of the tv-stand (on the left) and the shelf (in the right corner) require some specular reflection because in real life the wooden parts are covered with plastic. In picture 16 the influence of reflection can be seen on red wooden piece of shelf to make it look more like plastic covered.

Picture 16. Red wood shader without specular reflection (left) and with specular reflection (right).

In picture 16 it can be seen that the specular reflection makes the material more realistic looking and now it looks like it has some plastic covering. Approximately the same amount of reflection was added on material of the white wood pieces of the shelfs and tv-stands.

Diffuse maps are used for the couch, the floor and the brown wooden objects of the scene. Diffuse map can be any kind of bitmap image, for example taken with a camera, which determines the diffuse colour of the object. The diffuse images are also used as a bump map of these objects. Bump map uses a grayscale information of the image to create an additional shading without any additional geometry to the scene during the rendering process; the whiter is the area of the bump map, the higher the area looks on the surface. (Reallusion.com 2016).

Image 17 shows kitchen and living room with shaded materials and withouth any adjustments on camera settings.

Picture 17. Living room (left) and kitchen (right) with shaded materials, no adjustments on camera settings.

In the picture 17, it can be seen that the rooms appear a little bit over exposed, in other words brighter than they should. This can be adjusted with camera settings.

3.5 Adjusting camera settings

3.5.1 Daytime scene

So far the rendered images of this thesis are taken with default settings of V-Ray's physical camera. The size of the aperture is f/8, the ISO value is 800 and the shutter speed is 1/60s.

The depth of field in earlier renderings have produced good quality and therefore it does not require adjustments. One reason for good quality is the relatively short depth of field required; at maximum the distance between the camera lens and the farthest surface is less than five meters. Additionally, the aim is to create sharp image all the way through the room and not to target on some small details of the scene. In contrast, the case would be different if the room had been a long hallway and therefore the distance between camera lens and the farthest target had been much longer. Also if there had been some small decoration, for example a glass bowl on a table as a subject, it would have required adjustments to the depth of field and therefore to the size of the aperture.

The default shutter speed is already relatively fast, which is good for still images with a lot of light. As a result, the only setting to decrease the brightness seen in kitchen image of picture 17 is to decrease the ISO value and therefore the light sensitivity of the camera.

The picture 18 shows four rendered images of the kitchen with different ISO values.

Picture 18. Rendered images of kitchen with daytime lighting and with different ISO values. Other camera setttings are f/8 and 1/60s.

In picture 18 it can be noticed that with ISO values 800 and 600 the kitchen appears unnaturally bright and with ISO 200 the kitchen seems to be too dim for natural lighting. However, with ISO 400, the kitchen appears quite natural and the ISO value is therefore suitable for interior rendering with simulated daytime lighting. For picture 19 the living room is rendered with camera settings f/8, 1/60s and ISO 200.

Picture 19. Living room lighted with simulated daytime natural light and rendered with camera settings f/8, 1/60s and ISO 200.

3.5.2 Nighttime scene

As it was mentioned in section 3.3.2, the default camera settings of V-Ray's physical camera renders far too dark image of the nighttime scene lighted with practical lights (picture 14). Therefore, the exposure of the camera needs to be increased. As mentioned earlier, the depth of field is good for sharp interior images and therefore the size of the aperture should not be changed. As a result, the possible adjustments to camera settings are to increase the light sensitivity (ISO value) and to increase the shutter speed value.

However, the ISO 800 is already close to its maximum limits before making the image grainy and therefore increasing it even more is not suggested (Photography Life 2016).

As a result, the only adjustable setting is to increase the shutter speed value. Picture 20 shows the rendered nighttime living room lighted with practical lights with different shutter speed values.

Picture 20. Rendered images of living room with nighttime practical lighting and with different shutter speed values. Other camera setttings are f/8 and ISO 800.

In picture 20 it can be seen that while shutter speed values 1/60s, 1/30s and 1/15s give unnaturally dark results, the camera setup with 1/8s shutterspeed seems to produce fairly natural looking results. Therefore camera settings f/8, ISO 800 and 1/8s is suitable for nighttime shots lighted with practical lights.

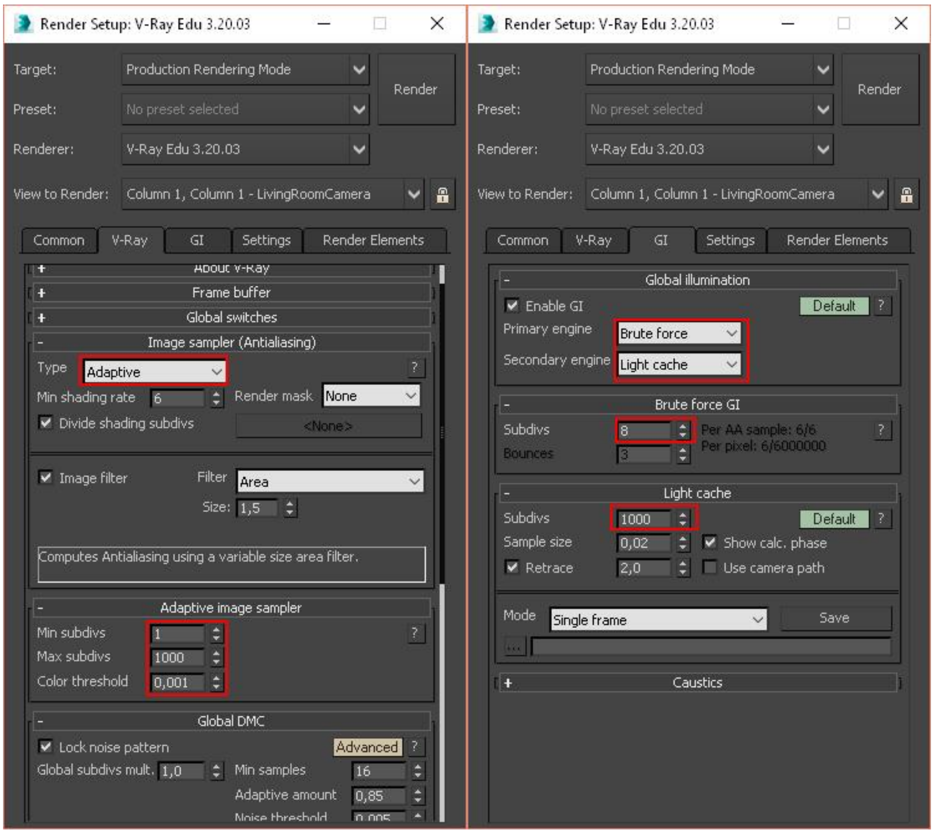
3.6 Adjusting rendering and GI settings

For the final renders of the daytime and nighttime scene so called ”universal” V-Ray settings will be used, because they are suitable for most of the scenes and and often produce high-quality results. (Chaos Software Ltd. 2016g).

Universal settings are the following:

- The image sampler is set adaptive and subdivision values are min 1 and max 1000 (Chaos Software Ltd. 2016g). The image sampler is responsible of primary rays ”sampling a scene’s Geomtery, Textrues, Depth of Field and Motion Blur” (Bilgic 2014).
- Colour threshold is set to 0.001 to produce less noise.
- The Global Illumination is enabled and primary engine is Brute force and secondary is Light cache and their subdivivision values are maintained as default which are Brute force 8 and Light cache 1000. (Chaos Software Ltd. 2016g). The effect of these engines have been discussed in section 3.4.
- Other V-Ray’s rendering settings are retained as default.

These setting adjustments can be seen respectively in screenshots of picture 21.



Picture 21. V-Ray’s Universal settings for rendering. The changes made to the default values highlighted.

In order to reduce rendering time some adaptations to the universal settings could be done as recommended in Bilgic’s blog (2014). However, in this thesis the aim is to create photorealistic renderings rather than discuss about the rendering times.

The image resolution for final renders are set to Full HD (1920px x 1080px) and the final rendered images of kitchen and the living room with daytime natural lighting and nighttime practical lighting can be seen in pictures 22-25.

Picture 22. The rendered image of living room lighted with daytime lighting.

Picture 23.The rendered image of kitchen lighted with daytime lighting.

Picture 24.The rendered image of living room lighted with nighttime lighting.

Picture 25. The rendered image of kitchen lighted with nighttime lighting.

4 CONCLUSION

The aim of this project was to create photorealistic daytime and nighttime lighting for an interior scene and render the scenes by using 3DS Max modeling software and V-Ray rendering software. During the project shaders were applied on a 3D scene, lights were adjusted based on a real reference apartment and camera settings were adjusted for the rendering. As a result nearly photorealistic images were rendered for both daytime and nighttime scenes.

Although this project has been just a scratch to the surface of photorealistic lighting and rendering, it has been very educational as a first lighting and rendering concentrated project. Now that the basic knowledge of lighting has been assimilated, the focus can be concentrated on the various settings of shading process in which especially the knowledge about realistic metal and fabric shaders are needed. Also the rendering optimizations should be investigated to reduce the rendering time.

Now when the lighting for the room interior is finished, the process of creating smaller objects and details to the scene can be started. Also the creation of bathroom can be started which was left out from this project because of its very complex geometry and shaders.

The time used for this project would have been shorter if an already modeled 3D scene was used. However, one purpose of this project was to create material for portfolio and therefore it was important to create everything from start to finish.

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