Narration of Light:
Computational Tools for Framing the Tonal Imagination

by

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Abstract

Existence of light reveals the architectural space. And images depict them.

This thesis proposes a computational model for evaluating tonal and compositional qualities of photorealistically rendered synthetic images. Its aim is to assist the architects to quickly externalize their spatial imagination through automated evaluation and selection of volume rendered images in search of the ones they like to achieve. Taking the visual perception as the focal communication tool in design, the research promotes the use of computer generated realistic images to the very beginning of the design process.

The implemented tool, *Narration of Light*, is a plug-in that runs on the 3D Studio Max 7 environment, where realistic images can be rendered without any evaluation for the generated images. The tool aims to create a more self-conscious rendering environment that would computationally recognize the qualities of image by reading it via bitmap values. The plug-in, while trying to determine the user's intention regarding the tonal distribution of light via any kind of user selected images, it also embeds algorithms of established photographical composition techniques to evaluate and classify the generated images. In the awareness of the strong relationship between space, light and images, this research intends to offer an alternative image-driven design process as well as going into the experimentation of evaluating the quality of images with computational means.

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1. Prologue

1.1. Motivation

In a black box with no openings to take light in, there is no vision. Those are the openings, which make an ordinary box or any enclosure an architectural space, as the light penetrates through them and creates traces and shades. Light and space have a mutual relationship since the architectural geometries articulate the light and light reveals the essence of the architectural space.

Architects imagine about spaces in awareness of sculpting effects of light. They design the spaces via processes and they witness envisions created in their minds' eye via images. Although the architects have a sensual image in their mind at the very beginning of the design process, this image cannot be revealed until the very late stages of design projects. In the process of realizing the imagination, architect sketches to depict the imagined. As the abstract state of thoughts develop into well-defined architectural entities, spaces can be represented in a realistic way with the help of high end rendering programs. In all states of design, images are one of the strongest communication tools.

Realistic images, with the power of life-like representations reveal the visual characteristics of the spaces with flawless precision. The more realistic an image is, the more information it embeds. A photo-realistic rendering communicates in a higher level compared to sketches or illustrations, and gives more information. However, these images are mainly used as post-design tools, for representing the built-already spaces.

1.2. Problem Statement

This thesis, proposing a computational model for enabling the architects to externalize their spatial imagination, evolved in awareness of the strong relationship between space, light and images. My personal consideration on the importance of visual perception in understanding the spaces drove me into this experimental study.

This study focuses on externalization of the spatial imagination via images and aims to break down the time span between the act of sketching and realizing the effects of light in spaces via visualizations. The demonstrative digital tool intends to offer a rendering environment with a certain level of quality recognition and evaluation. However, neither the model, nor the digital tools present themselves as proven facts or concluded products. Rather, they stand as products of an experimental study, in which the terms design-computation and imagination have intentionally been considered together for setting of the problem of Narration of Light.

2. Background

Framed by intending to create a model depending on experimental research of relationships between light, architecture and computation, this study also takes its roots from the thoughts about concepts and conceptions. The way the intellectual processes work, and the ways of the architects design, for me, are deeply related to the concepts. Before going deep into the research subjects, I will briefly talk about concepts and the way they built up the back-bone of this study.

2.1 Concepts and Interpretation via Seeing

We name the entities we perceive to classify and differentiate them from the others. When an entity is named in a way that we can understand and recall, it becomes a part of our knowledge. Knowledge is the systemized group of information, which we are cognizant about, and is available to us anytime since it is stored in the memory. For the creation of knowledge, we need to collect information, which is embedded in the environment surrounding us. The act of collecting of information happens via the tools we use to perceive things, by our senses.

As well as the information as the outcome of perception, the process of sensing or perceiving is also stored in our memory. The sequences of actions and interactions which happen in the process of perceiving things, build up our experiences. The goal we try to reach (information) and the process we run while doing this (experience) are both used later in recalling or understanding the entities or happenings. By accumulation of information via senses, we match some notions stored in our memory to the things we perceive. This creates the basic abstract ideas we have related to entities.

A more precise word referring to the abstract ideas we attribute to the entities in our mind is 'concept'. In other words, concepts are the abstract allocations in our memory which store specific information related to the entities. The entities are defined and classified by the existence of concepts. With concepts we name the entities or attribute keywords to thoughts related to them. Concepts help us to frame our understanding of an entity in a systemized way and allow us to understand things in a shorter time and describe them with fewer words.

The concepts attributed to different entities inhabit in the mind together and they give references to each other. Existence of a concept and the ideas embedded in it help us to structure other concepts and differentiate the concepts from one another. This way, concepts are also the source of the new ones. We re-edit re-arrange and re-combine the thoughts that were related to one or more previous concepts, and create the new one. According to Donald Schon, new concepts are nothing more than the combination or the transformation of old ones.[1] He

[1] Schon, Donald A. 1963. Displacement of Concepts. London: Tavistock Publications, 17-33.

claims that concepts are formed in the existence of the previous ones, and he names this process as the 'displacement of concepts.'

The new concepts can be formed in different ways taking the old ones as the source. While creating new concepts for new entities, we take whole or some parts of our previous concepts and create the new one by combinations. This way, the unknown becomes the known and get stored in our memory as a new concept.

2.2 Compositions: The Hill-House Chair

The world is a composition which in turn is composed of elements that are compositions. All the compositions can be broken down into the smallest bits and pieces that build them up. The interpretation of the world and all the elements embedded in it depend on fragmenting them into pieces, smaller elements, then naming them and recombining these many pieces to produce the whole image, which would give the main idea or make sense to our perception. The process of understanding the world can be described as decomposing and re-constructing it. So, as an individual, we store the information we get by decomposing the world, then recombine some of these bits of information in different permutations to create a meaningful entities.

To further describe the concepts and the way our mind deals with them, I will illustrate the process of interpretation of entities by using a design object, the Hill-House Chair designed by Charles Mackintosh in 1904. I prefer to use the images, which are rendered from a simplified digital model of the chair instead of using a photograph to express the notions of concepts in a clearer way. I expect the reader to follow the text and observe the image of the chair and the related diagrams simultaneously for creation of a visual experience of the object. (Figure 2.2.1.)

In a broad sense, a chair is a device we use to accommodate ourselves in a determined posture. In a more detailed and precise description, it is a type of furniture we use for sitting. It generally has four legs to elevate it from the ground, a horizontal part to sit on, and an articulated extension on the top to rest, which is called as the back. These are some of the features, which we immediately attribute to the entities we classify as chairs.

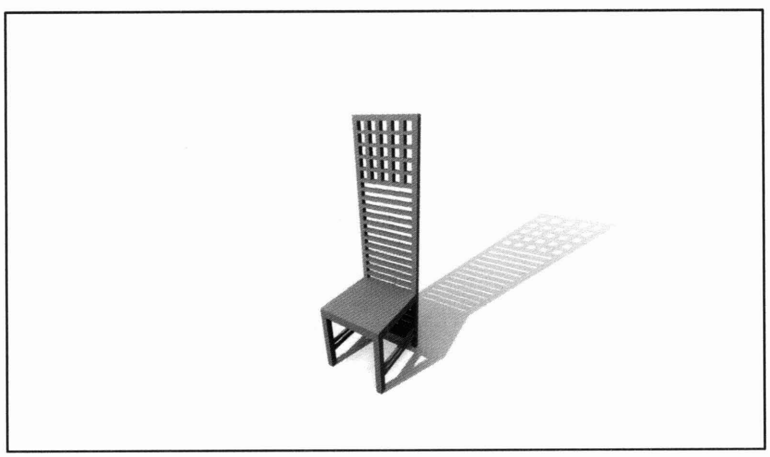


Figure 2.2.1.

Render of digital model of Hill-House Chair by Mackintosh, 1904

When we hear the word 'chair', we recall the features embedded in the corresponding concept for chairs. Similarly, when we see an entity, we compare its features to the features embedded in the concept of chair in our mind to decide if that is a chair or not. The concept of chair is linked to many concepts directly or indirectly like 'legs', 'back', 'seat' and so on. (Figure 2.2.2.) I will call these basic concepts that we immediately and easily attribute to a larger concept as a general sub-concept.

General sub-concepts help us to define the entities in an easier way. However, the amount of information supplied by those is not enough to define an entity precisely. The chair concept can be broken down into concepts which relate to its some other features that stimulates different perceptions.

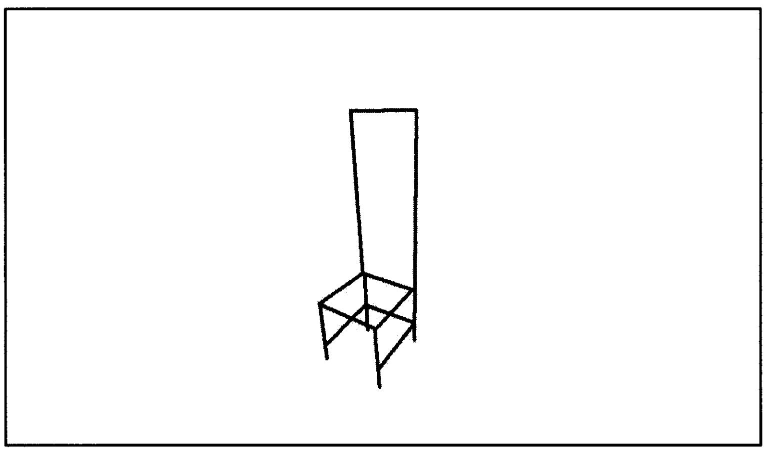


Figure 2.2.2.

Visual representation of conception of chair

The Hill-House Chair, representing the very basic features of the simple chair concept we have in our mind, can be described with other means, like its geometric specifications. Regarding the basic visual experience and knowledge of a perceiver, who has the very basic geometric concepts, the Hill-House Chair could be described in the means of lines. This definition however will not be enough to make a full description of what the Hill-House Chair is; not because it is incorrect but because it is deficient. We can still use the line concept to describe the chair, but we are in the need of adding more information to it to make the context clearer: 'Hill-House Chair is composed of parallel lines'. Here we clarify the character of lines by adding the concept of being parallel, thus we know that any coincidental configuration of lines can't build up this chair. Similarly, to define the top part of the back of the chair now we can say: Hill-House Chair is composed of *groups of parallel lines,* which are arranged as *perpendiculars* to each other.

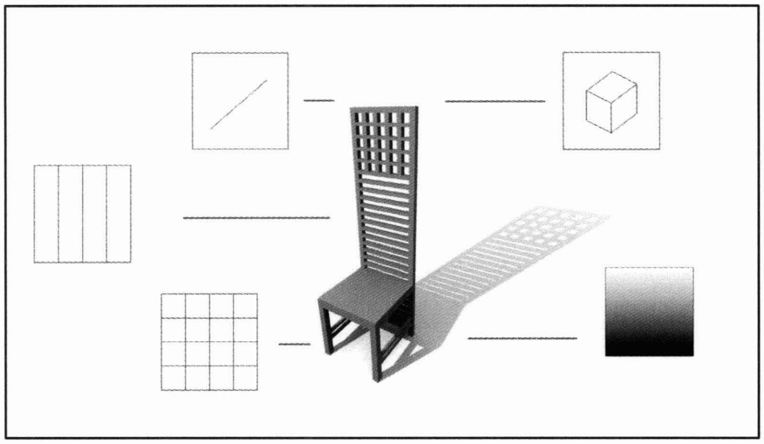


Figure 2.2.3.

Visual representation of varying complexities of the information embedded in the Hill-House Chair

The effort of detailing the geometric features of Hill-House Chair, make us understand it in a more detailed way. However, the three stages related to lines and their configuration I already mentioned above are still very simple two dimensional understandings related to this complex object. So, this object still can't be defined by this break down, since it is a three dimensional entity and since it also has many features in higher degrees of complexities like geometric proportions, material properties, color, softness, weight and so on.

Thinking about concepts, it is hard to define where the breaking-down of meanings could end. The depth of this recursive branching of concepts, even regarding the simple features of an object can't be easily handled. And we mostly think in neutralized conditions while performing the breaking-down. On the other hand, the real-life conditions extremely change the way we see and understand the things.

Here, I will give an extreme example regarding the condition of perceiving the Hill-House Chair via seeing. In the inexistence of light, the chair would not even be perceived, whereas a dim environment would give little clues about its geometric properties. A direct light hitting the chair in a specific angle would reveal more information about the chair, even creating a characteristic shadow which couldn't be perceived in the other two conditions.

Clearly, as well as the way the mind works, the external conditions are extremely important in how we see and understand or interpret things. In the following title, I will summarize the relationship between conceptions and design, and I will explain the effects of the external conditions on our design behavior.

2.3. Design Processes and Concepts

My interest in the design processes, and my aim to understand the ways we design created the fundamentals of this thesis. As well as intending to look for possible definitions for the conventional design process as systemized sequences of actions, I was also eager to search for possible ways that would lead the designers to alternative design processes. The abstract ideas of establishing alternative paths in design which would lead to different design experiences and products had an influence on this study. Before going deeper into the details, I would like to talk about design concepts and how alternative ways in design can be taken in the awareness of the way our mind deals with concepts.

The design process, defined either as a problem solving process or a problem setting one, is the set of actions with which designers try to outline their intentions and decisions for the achievement of a valid design product. Among the many parameters that define the course of a specific design process, the design domain, which is the decision or rule set employed in the design process, plays an important role in determination of the direction of the design. The design domain is created after the creation of an abstract idea that would drive the design process. This abstract idea is called as the design concept. It is very important to distinguish between the terms of concept and design concept, since the former refers to the abstract ideas related to understanding of the world, which I covered previously, whereas the latter one refers to the idea of design. While the two terms carry different meanings, the way of occurrence of the design concepts is similar to the one of concepts. Thus, our minds behave in similar means to that of interpretation of the world, while dealing with our understanding related to design.

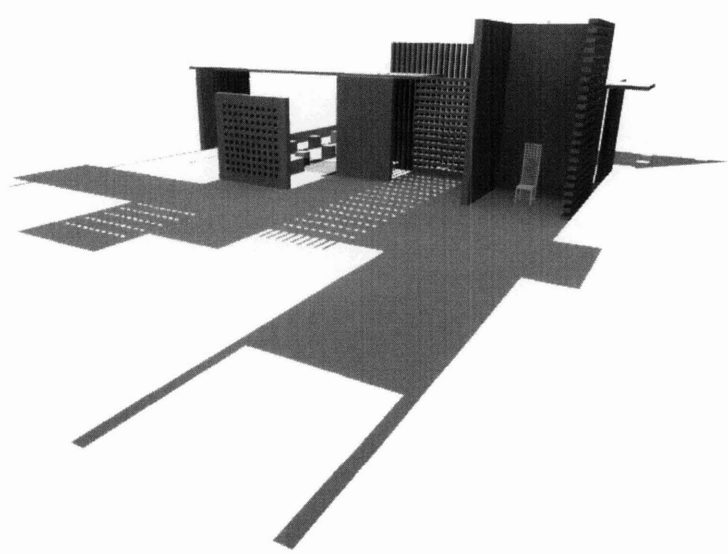


Figure 2.3.1.

An environment designed by taking the Hill-House Chair as the *design concept*

As one of the many possible definitions, the act of design starts with a question an in the process of design, this question is processed via a systematic and analytic sequence of decision taking. In this sequence, the question is first decomposed into its smaller components. In the next step, by combination of these components, it is transformed into a larger understanding.

2.3.1. Understanding Design Assignments

I will illustrate the action of breaking down a design question by taking one of the popular undergraduate design studio assignments as a sample. *'A House for an Artist'* is the title for an assignment I came up with at different institutions including Middle East Technical University (METU) in Ankara, Turkey and Massachusetts Institute of Technology (MIT) in United States of America. In the former one, I was an undergraduate student, but I was mainly observing the approaches of the students since I was working on a different project. However at Massachusetts Institute of Technology, I was a reviewer and I had a better chance to understand and define how such kind of design questions are handled by students. While explaining the actions taken by the students in the following paragraphs, I will call them as designers instead of candidates, since the process our minds runs is very similar regardless of what our position is.

'A House for an Artist' is a semi-detailed expression, and it asks for an architectural artifact with a specific requirement. The architectural artifact that is demanded by the expression can be better understood by scattering the expression:

The expression asks for a house, which is a type of building in which the people inhabit. It is not a house for somebody to inhabit, it is a house for an artist to do so. The designer already can name what a house is, depending on his or her experience, but now has to develop a relationship between the concept of an artist and the concept of a house to create a design concept that will run the design process. So the question suddenly becomes 'What makes a house, a house for an artist?' The designer now has to learn about the daily life of an artist, and what and artist would do in the house to be designed. The pieces of information that break down even to the details of the behavior of the artist are later combined into a meaningful understanding that would ideally create the appropriate design.

For a better understanding of what an expression is demanding for, as designers, we are in the need of seeing the parts we already know, so we can have some components in our hand that we can understand. Our memory and previous experience determine which parts will immediately be seen and understood. These understandings then create a set of inputs, which together with the design decisions and actions define the boundaries of design process. This set is indeed builds up what I referred as design domain previously.

While the first phase of scattering the design question creates the inputs for design, the second phase of composing, which is putting together, requires specific techniques. These techniques, including our decisions and actions related to design defines a *method* we work with. The methods we once use, like many entities related to mind, is stored in our memory. Working with a method for the second time is always faster and safer since we already can estimate and guess the happenings during the processes.

2.3.2. Re-Use of Design Process Paths

While designing, we generally are biased to use the methods we already tried for quick understanding and application. Taking a shortcut for constructing understandings makes us feel comfortable. Similarly, in the process of design, when we behave in our previous domains we feel safer. Designers create in a less painful process when they stay within their pre-defined design domains or their boundaries of experiences. This consistency is, on the one hand, useful for designers since it helps to understand the world of their designs: they do not have to build everything from the beginning every time we try to understand or create something.

However, many innovative designs come out of the shifts in the meanings of a type, that is, the shifts or changes of the basic concepts we have about design. Having no exact methodology, the creation of the design domain may depend on the different combinations of the designer's knowledge, previous experience, and mental conceptions. However, the constraints on one's thinking that come as a result of education, and training, along with those imposed by the designer's interpretation of the world, restrict the exploration of design.

Dealing with concepts and conceptions, with no doubt requires a broader study. However, their influence in design shaped my decisions during my research. As I explained formerly, I was already motivated for exploration of alternative design processes. Working on the concepts and the way our mind works made me see and understand the undeniable influence of our previous experience. It is my personal conclusion that an alternative design process would require alternative conceptions, alternative understandings, and alternative methods for design. However this thought have been defended by many other professionals, some of which will be explained in detail in the following chapter.

3. Alternative Design Processes

Routines determine the behavior. If one is a designer moving with his or her routines, it doesn't necessarily mean that the one is not a good designer. However walking on the same path would make it hard for the one to create something different, something that we haven't done before. What I refer as different here is something, which adds onto ordinary by its existence, which is not usual or conventional.

In the discourse of design, a new design artifact, which has positive sides compared to the conventional, and which is a result of new processes and approaches in design process is called 'innovative'. The dictionary definition of innovation is the process of making changes to something established by introducing something new. And we may define innovative as the one that uses innovation for development of tools, techniques and methods while running productive processes.

Innovation requires the new. It requires the method which was not tried; it requires the path which was not taken. It requires answers which were not considered and it requires the thoughts which were avoided.

3.1. What a Chair Could Be

A chair, as I mentioned at the very beginning of the concepts chapter, is a device we use to accommodate ourselves in a determined posture, it is a type of furniture we use for sitting. But here, I will totally oppose the general features that our mind immediately attributes to the concept of chair: A chair does not necessarily need four legs, even any legs to be elevated from the ground. It doesn't need to stand on the ground, the seat does not necessarily have to be horizontal, and the definition of the back of the chair can change as well. (Figure 3.1.1.)

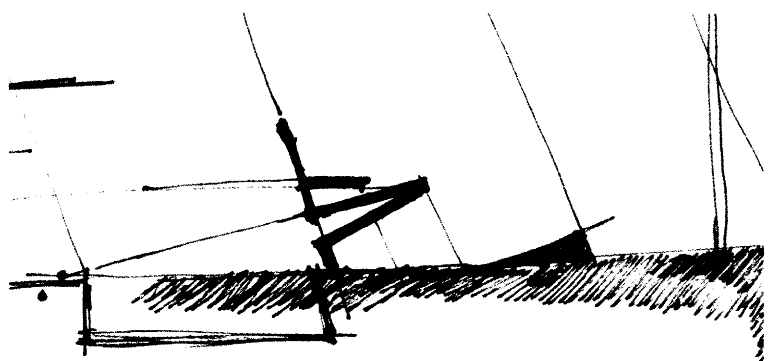


Figure 3.1.1.

Sketch for an alternative chair design. This exploratory drawing is not necessarily addressing all the solutions for a new design.

If a designer starts dealing with a design question by accepting the already established intellectual systems and processes, he or she searches for the difference not in the essence of the design, but in the superficial parts of it. If we start the design of a chair accepting that it has legs as the only support that holds it standing, we start playing with the geometry, proportions and other features which are related to legs. But then, the variety we look for is bounded in the limits of the concept of the 'legs'.

'The Edge' was my first furniture design, which was developed under the influence of inquiries related to concept of chair. Starting with initial sketches, I was looking for alternative ways to make a chair stand on its own and in the existence of somebody sitting on it. These were the two basic considerations for me, and I tried to avoid some other concepts to work on a freer basis of design. The chair I came up with touches the ground on one point, where it is fixed at that specific point (Figure 3.1.2). The balance of the chair is provided by an additional support at the back which can be attached either to a larger mass or to fixed entities in a space like walls.

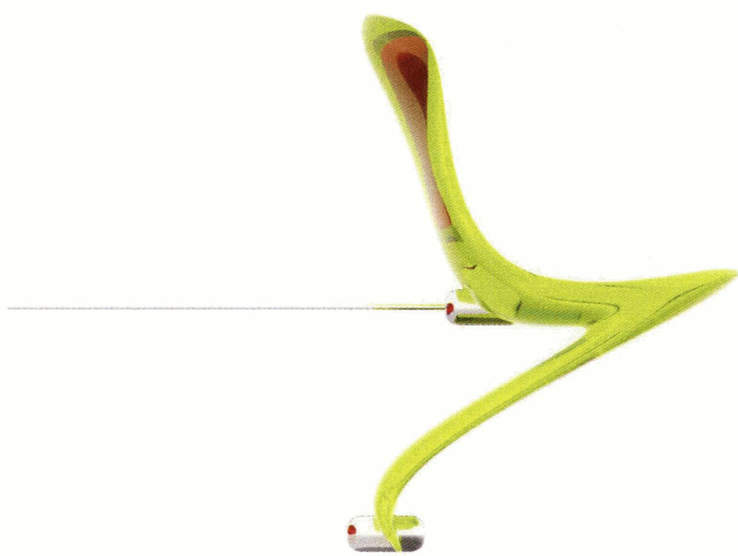


Figure 3.1.2.

Final render of 'The Edge' from the side.

One of my other concerns was creating the chair as one single entity where the parts would merge into another to build up a unified entity with a purified form. This approach was taken by many designers in furniture design, and is already widely known. I also wanted to focus on the use of an unconventional material to see how the visual quality of chair could change.

I don't claim that The Edge is an innovative design. I don't claim that it is a good design, either. But it has some different qualities compared to the chairs we are used to see or recall when we hear the word chair. It has some information in its design, which is not usual for conventional chair. And this information is there because it was searched intentionally, because this chair was designed in an awareness of the limiting effects of the concepts we have.

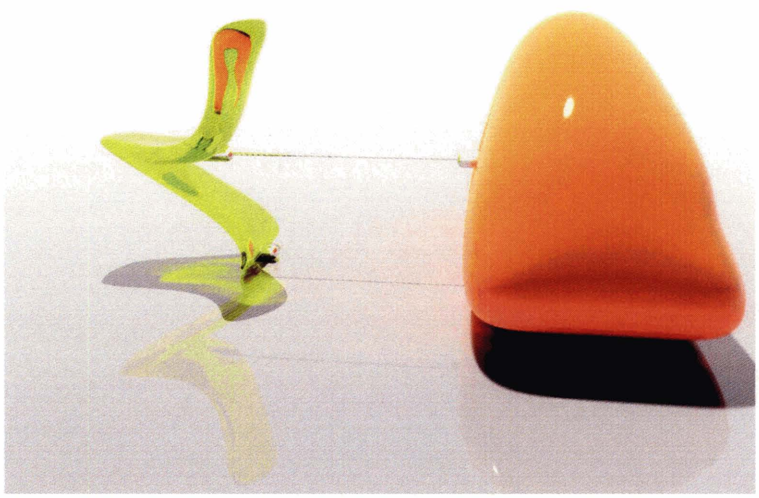


Figure 3.1.3.

Final render of 'The Edge'. An alternative concept for a chair.

The awareness of the limitations of our habitual design environments is one of the greatest concerns of American Architect Lebbeus Woods. Woods is famous with his envisions and his experimental architectural processes and products. Woods talks about the 'reassurance of habitual' [2] and mentions it as a negative aspect for the design, which prevents the designers from putting all their effort into design. According to

[2] Myers, Tracy, Lebbeus Woods and Karsten Harries. 2004. Lebbeus Woods - Experimental Architecture. Pittsburgh: Carnegie Museum of Art.

Woods, repetition of our habitual behaviors disables the creation of innovative designs, since it sets back the search of creativity in unknown fields. In the following chapter, I will describe Woods approach to design in detail and the way he motivates alternative design processes by this approach.

3.2. Images that create Environments: Lebbeus Woods

Lebbeus Woods, while explaining his work, "experimental architecture," proposes alternative statements about notions of what architecture is and how it should be approached. He claims that the final product of an architectural process is not necessarily the realization of a constructed building that people interact with or live in. Instead, an architectural process may end up with a single section drawing, or a single model, independent of any drawings or scale. For Woods, the path of exploration and the experience of creation is the essence. According to Woods, if a designer could free his mind from the cult of thinking of architecture as generating buildings and could motivate himself through the creation of models and drawings as the final architectural artifacts, he would be experiencing a more creative process. The change in the very basics of design thinking re-forms the design domains of the designers, which may lead them to different end products. Talking about his own practice, Woods explains his vision and action as a shift to free himself from the 'reassurance of the habitual', not as a simple rejection of the forms or rules of architecture. By approaching the design process in an alternative way, Woods creates a design language of his own.

In his practice of 'experimental architecture' Woods defines a new ground for himself to deal with his questions of architecture. Images have a great importance in his work, as he sees them as the architectural artifacts. Sometimes, the abstract depiction he creates with images later transforms into scale models or installations. (Figure 3.2.1. & 3.2.2.)

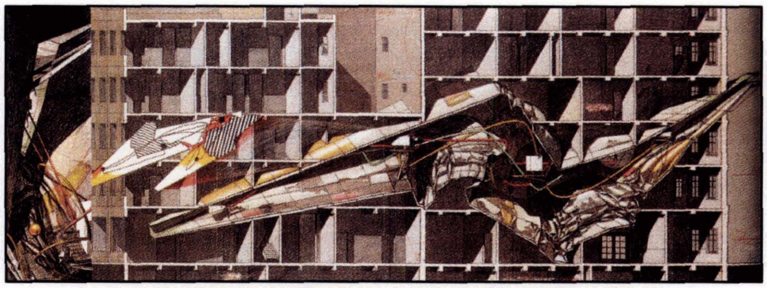


Figure 3.2.1.

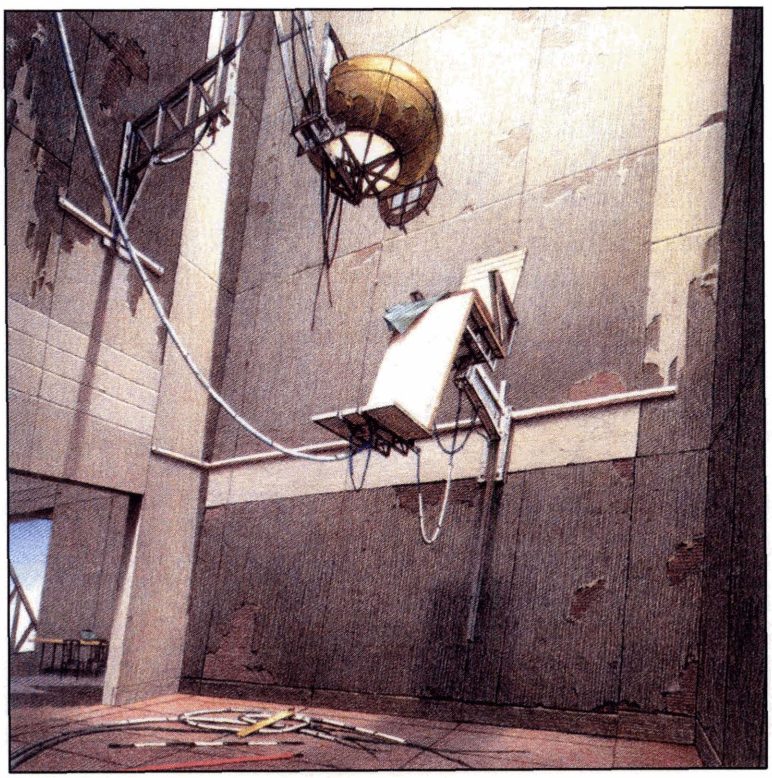
Woods' drawing from 'Berlin Free Zone' Project

Figure 3.2.2.

Scale models of Woods' creations

The images Woods creates are generally provocative that present his ideas in a very clear and direct way, regardless of the conventional requirements of architectural drawings or representations. He works on different scales and not necessarily obeys the established techniques and conventional design facts, as in the injections he made in the 'Berlin Free Zone' project (1990 - 1991). In this project Woods injects free spaces of free-form metal structures into the existent building stock. As well as disregarding some real-life references, images of this project still become real depending on real backgrounds, real sites and more importantly real-life problems and concepts, rather than being totally imaginary creations.

These images, being precise externalizations of imaginings, evoke very strong feelings in the viewer. For some, they are very appealing whereas they are doubtful for some other. On the other hand, in Woods' drawings, the idea of the creator becomes so perfectly externalized on the canvas thus, for the curios viewer, understanding the unconventional idea becomes more important in comparison to the apprehension of the unacceptable.



<u>Figure 3.2.3.</u>

Neomechnical Tower Upper Chamber by Lebbeus Woods.

One of Woods graphite and color paintings, 'Neomechanical Tower Upper Chamber' (1987) was used in creation of the interrogation room scene setting of the movie '12

Monkeys' (1995)[3]. This film setting was constructed by taking the graphite painting as the only source and it was constructed without any conventional drawings or use of any kind of models. The image was used without the permission of Woods, so the setting was created without any reference from him. Here, I will not go into the ethical discussion about the situation. But for me, it is important to understand that one single image can be strong enough to construct a space, or build an environment on its own. A strong image can generate its own depiction.

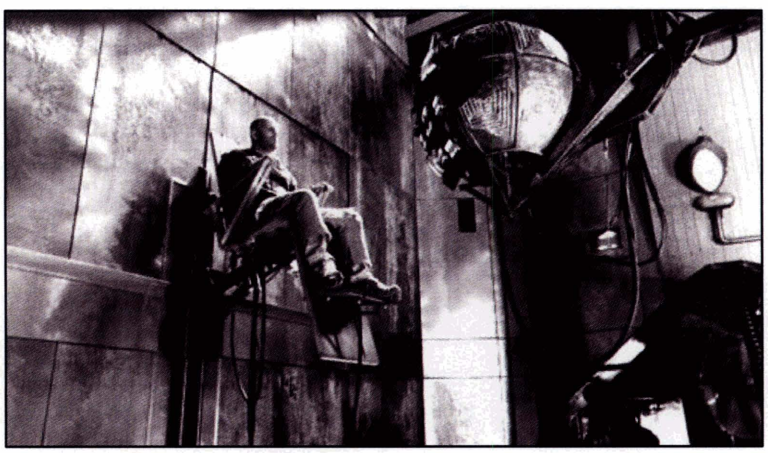


Figure 3.2.4.

12 Monkeys by Universal Studios, The Interrogation room scene

3.3. Images that create Environments: Peter Gric

Czech-Austrian painter Peter Gric also played an important role in my motivation related to my studies in images depicting architectural entities. With an inspiration from one of his paintings, 'Promenade' (1994-1995) I made an individual study to better understand how images can outperform themselves and generate spaces. My consideration was to first

[3] http://www.coldbacon.com/art/lebbeuswoods-12monkeys.html, [Accessed April 12, 2006]

answer if an image could be transformed into a space or not without any other references.

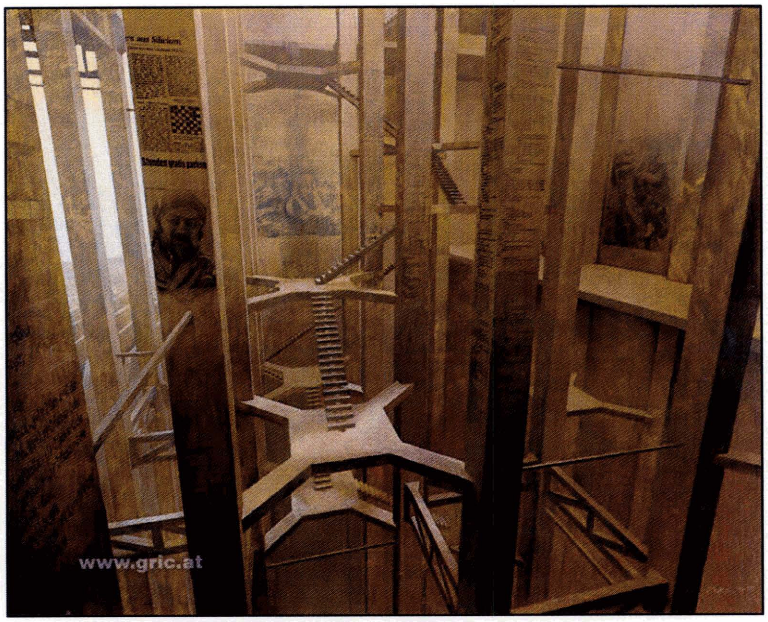


Figure 3.3.1.

Promenade by Peter Gric. Collage-acrylic on Fiberboard

Here, my intention was to create the space that evoked in my mind by seeing this painting. This should not be mixed with other computational techniques for development of three dimensional digital models by image processing.

I built a three dimensional digital model in 3D Studio Max by very conventional means and just by looking at the picture. I was very motivated to quickly prepare a simple model of the space depicted in the picture and try to catch a similar ambiance in the means of light and textures. My greatest concern was to see the other images that would be extracted from this digital model by changing the angle and point of view of the camera. I was wondering if an image could generate different images that would evoke similar feelings.

In the specific case of 'Promenade', the ten second animation, in which the camera was moving in the vertical axis, I was able to catch the similar sense of 'depth of space' which was already existent in the painting itself. The outcomes of this experimental study are totally open to discussion in the means of catching the quality original images since the aim was experiencing the process of constructing the a space in guidance of one single image, rather than trying to catch the maximum visual resemblance with the original image.

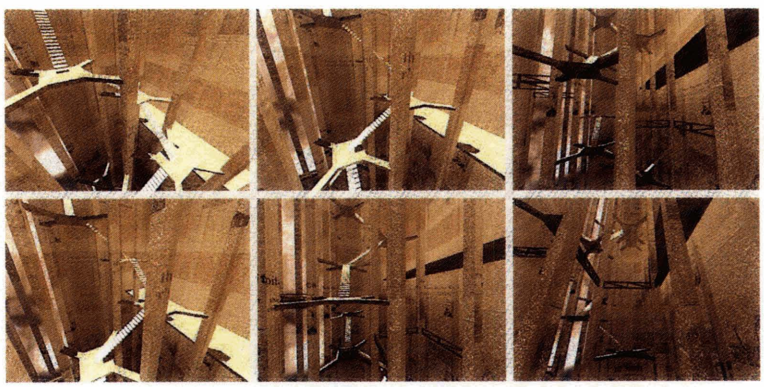


Figure 3.3.2.

Renders of the digital construction of Promenade

As in the examples I have described, creative processes can be driven by images and strong images may orient us into processes by the feelings, thoughts or concepts that they evoke in our minds.

4. Spatial Imagination

Imagination is one of the basic requirements for creative processes. As a brief description, imagination is power of creation of mental images and ideas. These images and ideas does not necessarily have to be existent in our knowledge, on the contrary they are created by references to the existent information within the knowledge. The product of imagination, which is the mental image created in mind is visible via mind's eye and externalized over time via descriptions, representations and so on.

The idea of architecture develops around the notion of space and the architects imagine about spaces. The mental images architects create give direct references to enclosures, scales and environments related to human beings.

What we call an architectural space is a differentiated entity within a larger one, namely a bounded or defined space within the universal space. What makes an architectural space an architectural space is the essence of being bounded. The boundaries not only separate the defined space from the universal space but also characterize it within the uncharacterized one.

4.1. Form as Identity

The specific character provided by the boundaries of space also differentiates it from the others. And this specific character is created by the features of the boundaries, one of which is their form.

Form is the shape and structure of an object, the body of it or its outside appearance. Form, addressing our visual perception, is one of the most influencing features of an object that characterizes it. Perceptually speaking, form embeds and depicts the configuration rather than contended.

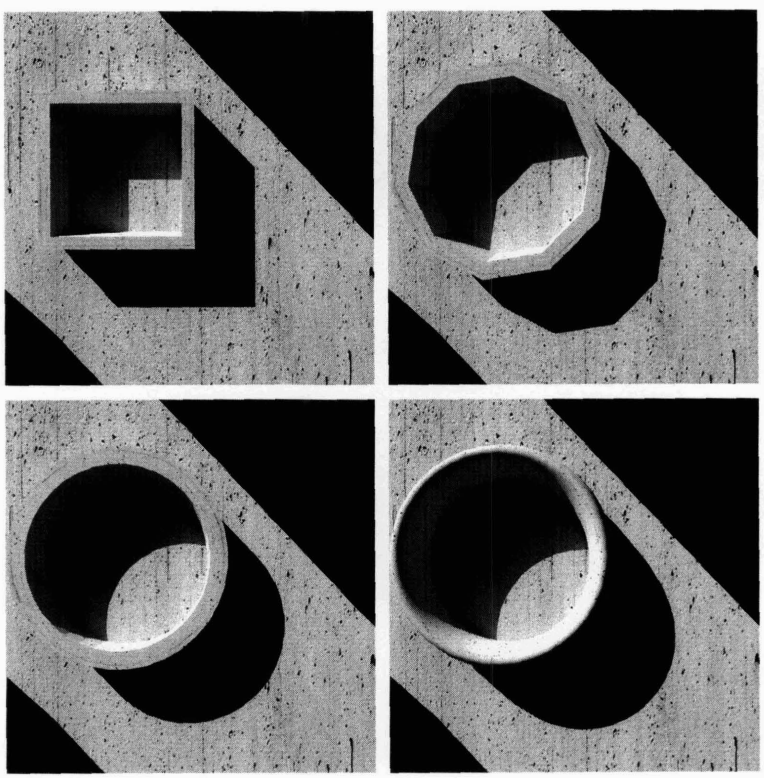


Figure 4.1.1.

Different forms and their interplay with light. Inspiration from photography of Helene Binet.

Form helps articulating the space. Spaces talk via the forms defining its boundaries. And they directly talk to our eyes;

we understand a space when we see them. Seeing literally is the everyday name of our visual perception, which is nothing more than the detection of light on retina. In a black box with no openings to take light in, there is no vision. In fact those are the openings, which make a 'box' or any enclosure an architectural space, as the light penetrates through them and creates traces and shades.

The terms used in the previous paragraphs including but not limited to space, boundary, form, geometry, light, opening, penetration, shades, and so on, describe the concepts related to imagination, which are connected to one another with complex relationships and multi-faceted attributions. One of each these terms may define or take palace in the description of the other. However the two terms, light and space have the most important attributions to each other since the essence of a space is revealed by light.

4.2 Light and Space

Spaces are designed in regard to light and the light makes the spaces *real*. We experience the spaces with the tones we see, the traces of light and shadow we read. Light animates the spaces; it gives information about the place and time. It reveals the intentions of a designed space, it highlight the sharp edges and smoothes the curvatures.

But space is not a simple entity which interacts only with the light. It has many components, it envelopes other spaces, objects and inhabitant. While looking for the right word that would describe the space-light relationship with all these sub components, especially indicating the effects of light, I came up with the word 'atmosphere' in Henry Plummer's book. In Masters of Light, Plummer is describing the how the interest in the effects of the tones of light created within a space influenced the modern architecture. He states that the modernist movement focused on the total feeling that would be created by the articulation of light. Here, I will refer to his depictions about light and space rather than discussing his statements about the modern architecture. Plummer makes a very insightful and pure description of the atmosphere by explaining it as the 'close harmony of tones'. He claims that these characteristics of the tones actualize the overall affection of the space.

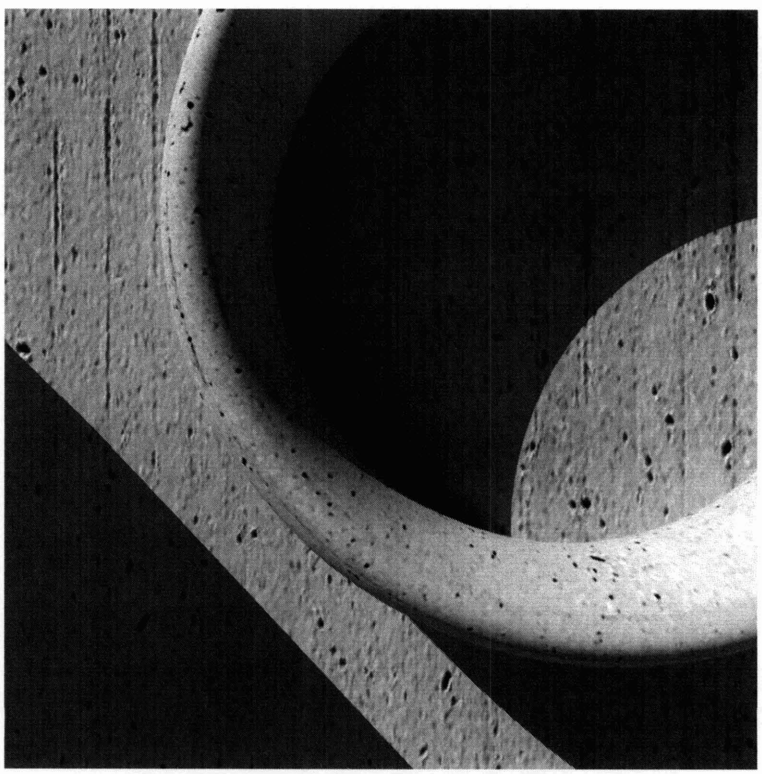


Figure 4.1.2.

Importance of shades in defining forms

The keyword to my interest in Plummer's definitions was the word tones, and it was depicting the thing I was trying to put forward in my study. In conventional thinking, only light and shadow are underlined as the revealer of the spaces. However, the tones in a space, the dark and bright scales of grey, their amount and distribution define a space as much as the traces of light, and its contrasting element, shadow. I will talk about the aspects of light and the way I tried to handle with the tonal intentions in design in the following chapters.

5. Images and Architectural Processes

Architectural processes run depending on specific sources and are driven by some other. The concepts and thoughts related to design are put together and developed into a composition via determined techniques and by use of appropriate tools. Some intermediary outputs of the design processes are vital to the development of an idea into a product and they generally behave as the catalysts of design. The concept drawings, massing models, renderings can be counted as some of these intermediary products, with use of which we evaluate the designs in that specific phase. Depending on the results of this evaluation we update, change and enhance the design.

The two dimensional representations architects create and use during the design processes play an important role in design communication, thus they are one of the most important catalysts of design.

Under this title, I will refer to any two dimensional representational creation belonging to the architectural design process as 'images' regardless of their maturity and complexity. In the following paragraphs I will classify the image types that are used in the different stages of the design process and explain how they effect the development of the design.

In the different phases of design process we refer to and use different type of images, depicting different things in various levels of complexity, depending on the state of the design (Figure 5.1.). Here I would like to clarify that, the complexity of the image depends on the state of the design –not the complexity of it. Since the amount of the information increases directly proportional to the development of the design, the images describing and depicting that design also have to get mature enough to be able to express the amount of the information embedded in the design. A complex image does not necessarily mean a confusing or unclear one. A very pure image can also be very complex if it can express the information embedded in the design.

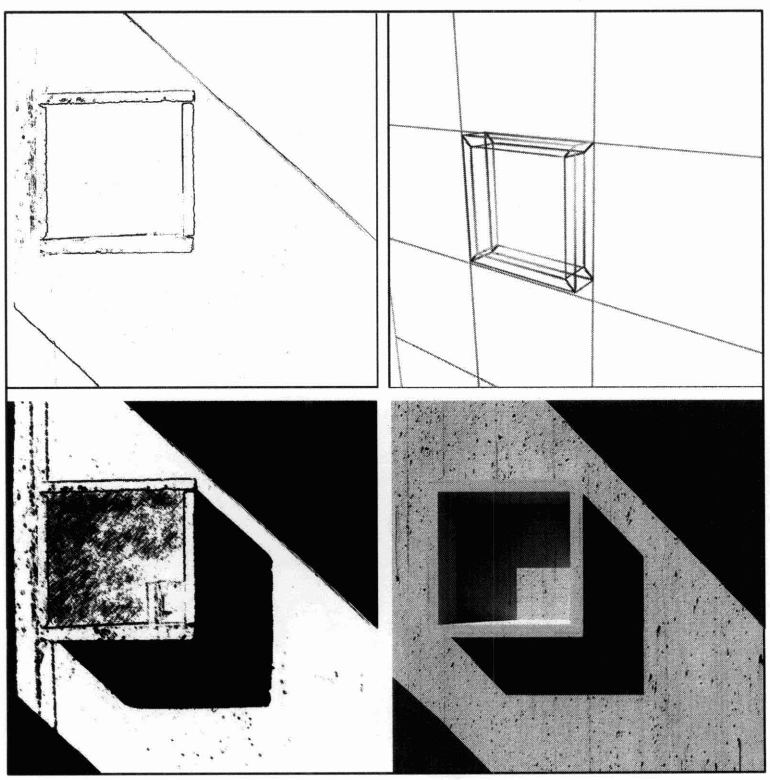


Figure 5.1.

Different two dimensional depictions used in the different stages in design: A sketch, an axonometric drawing, an illustration and a render

We perceive the images with all the information embedded in the two dimensional canvas, as a whole. It is hard to define the amount of the information in an image and distinguish between them. A good example to explain how we take our references from the pictures would be the situations in which we try to communicate via images instead of words. In the processes of architectural design, sometimes we refer to photographs of previously built spaces or buildings to describe our intentions about design. The subject of the communication we are trying to build can be ourselves or the others. To understand our own intensions via visual communication with images, we run through them until we *see* the thing that we were looking for or until an image evokes the feelings that we had in the image in our mind's eye. In the communication with others, we show those kinds of images and try to explain our intentions about design using the information embedded in those images, and by using simple expressions. We point the part or whole of the image and say 'something like that.'

In fact many things related to our design idea lies under this 'something' we try to refer to while showing the image. However, it is hard to define what we like or refer to in an image. Thinking about an interior space perspective, what we like can be the proportions on the space, the distribution and the character of the light in space, the location of the objects in the image and so on.

Spaces can fully be understood via one to one experience. By only being in that specific space, we can perceive all of its aspects. However an image also gives vast amount of information about the space since it addresses the visual perception. The information that can describe most of the features of a space can't be expressed via any kind of communication technique other than seeing. Thus, whatever we are referring is,

We have to see to evaluate.

I make this statement to provoke the importance of the images in design processes. Morover, I strongly believe that the images define the path of architectural processes unlike any other kind of tool we use. And because of this we run all the phases of design with the help of images, starting at the very beginning, by sketches.

5.1 Sketching

In the very initial phase of the design process, the immediate two dimensional productions architects create are sketches. We can define sketch as the quick documentation of the ideas. Sketching is rather an abstract depiction of the design intention.

In the act of sketching, the architect tries to externalize the thoughts related to design through creation of abstract figures. The level of the freedom of the hand sketching the idea decreases while the design ideas and intentions reach to a more solid state.

The multi layered lines creating a sketch are mostly undetermined and not fixed to be updated or modified by darker and stronger lines. While the sketch starts appearing on the two dimensional medium, the architect witnesses the idea of space by realization of dimensions, boundaries, geometry and even with some lines depicting the existence and effects of light in space. The sketches help one both to communicate with oneself and the others in the early states of design processes.

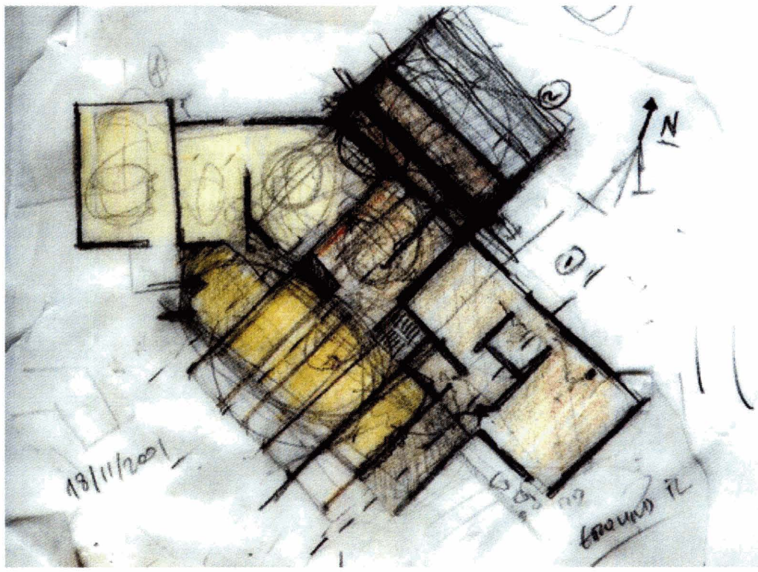


Figure 5.1.1.

The overlapping lines in a sketch serve for externalization of the design intention.

5.2 Intermediary Images

The process of design, with conventional understanding continues with better-defined drawings. Here, I will not go into the discussion of 'drawing-less design process', which refer to the design processes that run only with Computer Aided Design (CAD) models, without any two dimensional drawings. What I refer about the drawings are the images that are generated with those drawings. Similarly a screenshot of a digital three dimensional model can be considered as an image, too. So, even a drawing-less design process generates images.

As the design idea becomes mature, the images also reach to a higher precision via use of proper techniques. An axonometric drawing for instance, which also is a type of image on a two dimensional canvas, is the basic and abstract description of the geometry. The fact differs an axonometric drawing of a design from the sketch of it is the pre-established rules in the creation of that drawing. While the freedom in understanding or interpreting the composition of lines in an axonometric drawing is lost compared to the sketch of the design, the precision of information is increased.

A perspective drawing, compared to an axonometric one embeds and exposes more information. The colors and tones, if the drawing is enhanced by use of them, give more clues about the geometries, spaces, proportions and so on.

Prior to creation and use of digital technologies for rendering, the professional illustrations were the final images to represent the architectural product. These final images were created by different analog techniques including but not limited to airbrush, graphite, charcoal, pencil drawing and so on. These conventional representation techniques, still keeping their validity in some application, mostly left its use to computer processes renderings.

5.3 Realistic & Photorealistic Images

Photorealism is characterized by the high degree of likeness between a depicted image and a photograph, typically facilitated through the meticulous depiction of detail. A realistic image is the image which creates the sense as if it was captured from a real-life scene. The difference between the terms realistic and photorealistic is their proximity to reality. What a realistic image, is almost real, and creates the very basic feelings and perceptions of a photograph. But it can still be differentiated from a photograph, whereas a photorealistic image can hardly be labeled as an artificially created image or a photograph.

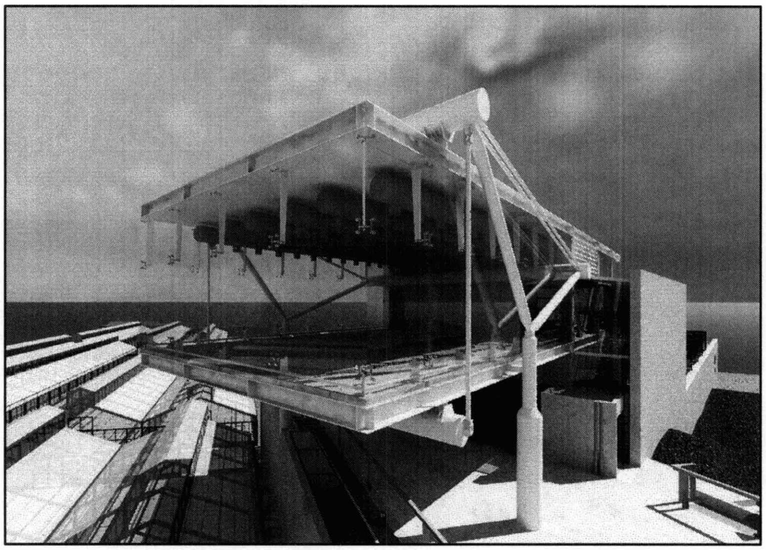


Figure 5.3.1.

Photorealistic render of Gushikawa Orchid Center by Associate Professor Takehiko Nagakura, MIT

The realistic and photorealistic images take all their references from real-life and conditions. The state of being realistic or not is defined by the strength of the image in expressing the life conditions in the most realistic way or not.

Photorealism started as an art movement in nineteen sixties in Europe and America, and the term now became associated with digital art and computer generated renderings, which are all named as Computer Graphics (CG). The term 'rendering', formerly referring to the drawing technique with texturing and shading, started to be used for the specific computational process, where an image is created pixel by pixel from a digital model and a scene setting. Here, what I refer as a scene setting is logically similar to the settings we use while we are taking photographs or shooting movie sequences. The cameras, lights and other devices or entities are created in a synthetic way to simulate the conditions we have in real life for creation of images with desired conditions.

Figure 5.3.2.

The photograph of the actual building in Gushikawa by Associate Professor Takehiko Nagakura, MIT

The development of the Computer Graphics technology started in the early nineteen sixties, and continued with an extreme acceleration due to the demand in the application areas like scientific and medical simulations as well as areas of entertainment like video gaming. Today, one of the largest application area is the movie making, in which Computer Graphics are used in creation of un-seen, un-experienced or mythical environments with the utmost realistic precision.

The development of Computer Graphics changed the ground for representation in architecture too. Besides the stand alone rendering packages, the three dimensional modeling and drawing software packages started being offered by additional rendering packages. It was a great advantage, to build a digital model and to be able to use it for different purposes including representation via rendering.

Rather than the advantage of multi-use of a single model, the experience of visual quality computers produced was appealing. Within the last decade, computers made the environments visible to the architects with flawless precision before they have been built.

Today, the high ends Computer Graphics Technologies enable us to create the visualizations of environments that are identical to real ones. The simulated artificial and natural light, the reflective and the textural qualities of the materials, any kind of climate condition that can be adjusted makes the environments and the spaces become real in the digital environment. We perceive these environments and spaces via realistic or photorealistic images, or experience them via video sequences. Due to the communicative power of the realism in the images, Computer Graphics are enthusiastically used in both academic and professional environments.

5.3.1 Realistic Images in Architecture

Computer Graphics Technology brings much more than the creation of appealing images into the field of architecture. Representing the space precisely, these graphic productions carry the potential of revealing the perception of the space. Computer generated realistic images endows the architects with the information for perception of the space without entailing construction. One can see a room of a house, a corner of a building, or perceive the depth of the space via computer generated images. One can precisely visualize what he or she envisioned, can evaluate and judge it by seeing.

But the graphics created by computers can also be deceptive if the references to the real world are not constructed precisely in the simulated world. However accuracy, especially if the aim is experiencing the space carries a big importance. The quality and the accuracy of the resulting image depend on the technical capabilities of the author, as well as his or her mental power of selecting the images with appropriate qualities. In the following paragraphs I will describe these factors that effect the process of image creation.

The high end rendering programs of our time offer many built in facilities and options to simulate the real life conditions. Higher precision or proximity to reality is generally achieved by adjustment of high number of complex parameters to take full control of the conditions in the environment. Due to this complexity, the proper use of most rendering programs requires a determinate level of expertise. However, in many processes that aim the creation of a realistic image of an architectural space, the sequences of actions are more or less the same regardless of the program used. While some changes may apply, a common process runs as follows:

1. The user prepares a three dimensional digital model of the space being designed.

2. If the user prepares the model in a software package that comes with rendering capabilities, the next step

consists of preparation of a scene. If not the user transfers the model into a rendering environment.

3. The user creates a scene. This scene is the simulated version of the settings used in real life like the settings in photography and movie making. A scene in the rendering environment is prepared by use of several objects:

    a. Lights: User selects the proper light for the setting. The rendering programs come with different light choices and different algorithms for calculating the behavior of light. These algorithms can be found in the program as different selections and can be selected via user interface. The lights and algorithms are generally determined together since different combinations effect the result in different ways. As an example, the Radiosity plug-in, which is one of the available algorithms in the render interface of 3D Studio Max, would be the appropriate selection if the user is aiming to produce a sequence of images, which will both show interior and exterior spaces. On the other hand, if the user wants to show a pool with its dramatic caustic effects, Mental Ray would be the appropriate selection, since this algorithm is capable of simulating the behavior of photons in transparent and translucent materials. The selection of the appropriate light and the algorithm also requires experience and a level of expertise.

b. Cameras: The cameras are the objects that determine the point and angle of view in a rendering scene. The cameras have the properties of real cameras like different lens sizes, depth of field and so on. If the intended product is a sequence, the cameras can also be animated depending on a timeline.

4. If the algorithm selected requires a pre-processing before starting the rendering process, user runs this, if not rendering starts.

Each program offers different detailed settings and the user adjusts these settings according to the outcomes.

Creation of a good image via rendering, like many technical applications, requires a strong knowledge and experience. However, a more crucial point is the capability of being able to determine the validity of an image. The rendering programs can render anything, regardless of what the result is, and computationally they are not aware of the result. The validity, or goodness or badness of an image is checked and confirmed only by its author via visual perception, if not criticized by others. While the real life conditions can be simulated easily by a quantitative approach in computation, it is hard to define the quality via numbers.

In the next chapter, I will move into the field of photography with an effort of setting a possible basis for definition and differentiation of qualities of images.

5.4 Photographic Image

Photography is creation of pictures via capturing the play of light and its effects. Technically, the reflected light from an environment falls on a sensitive surface, on which it is chemically or digitally processed. The word photography comes from the Greek words 'phos' and 'graph' and the combination means 'drawing with light' or 'representation by means of lines'.[4]

A photograph is the product of photography and it refers to the two dimensional medium, on which the image is printed. However, today the word 'image' is used almost as the synonym of photograph due to the rapid development of digital photography.

The term photography also refers to the fine art branch related to photography. As in all types of art, which makes a photograph an art piece is a wide discussion through which I will not go in this thesis. Here I would like to clarify that I focus on the quality of the photographs and images in the way they represent the spaces, which should not be mixed with the artistic value of them. In common sense, some photographs are better than the others, they are more admirable and sometimes stronger. I disagree with the notion that a beautiful picture is a good one. Rather, there shall be an essence which makes a photographic

[4] Wikipedia, the free encyclopedia webpage, http://en.wikipedia.org/wiki/Photography, [Accessed April 30, 2006]

image a good one. In the following paragraphs, I will talk about the quality or qualities that make a photograph a good one.

According to Andreas Feininger, as he describes in his book 'Principles of Composition in Photography', a good product of photography can be evaluated in the terms of 'technique' and 'art'. Amongst two, the former one is easier to understand and apply, since it can be quantified with objective evaluations. For instance, the sharpness of an image or the brightness-darkness of a photograph can easily be adjusted via the tools and techniques used in photography. The instruments, like cameras used in photography already introduce these adjustments tools like focal length of the lens, shutter speed and exposure. While developing a photograph or manipulating a digital image with digital tools, the quantities are already determined and we use them in order to achieve the desired result. However, the latter term is more subjective, and it is even unclear in a broader sense, since the word 'art' brings many different depictions and discussions with itself. In the definition of a good image, as I mentioned, I will take the photographic image as a composition rather than a piece of art. In the quantification of the value of image in the means of goodness, accepting it as a piece of art creates many setback due to the subjectivity of what we call 'art'. On the contrary, a composition can be divided into its components, as in interpretation of concepts, and can be evaluated regarding the values of these components, and the ways they come together.

Regarding the arrangement of the compositional elements, photography can also be described as the pleasing arrangement of subject matter elements within the picture area.

The composition of photographs depends on various terms like position of the camera, angle of view, contrast of the image and the tonal gradation and so on. In a good image, the composition reveals the goodness of the configuration rather than the goodness of the contented. In other words, a photograph including a beautiful object is not necessarily beautiful. On the other hand a good composition creates a good image. The contended can be beautiful, ugly or even disturbing. But the way it is framed in the boundaries of the canvas evokes feelings of different strength.

In a photographic image, the composition is embedded separate then the represented. The represented, in other words, the meaning is effected by the composition, however, the composition not necessarily have to include a meaning. To illustrate this idea, I will refer to the paintings of the Dutch painter Piet Mondiran (March 7, 1872 - February 1, 1944), where the geometry and color came together to express an absolute composition regardless of any representational concern. Aiming to express the feeling with full awareness, Mondrian used rectilinear geometries and colors to create his compositions.

In the evaluation of Mondrian's paintings, we refer to the proportions of the rectilinear geometries, the thickness of lines and their directions and positions. The tension or the harmony of colors also evokes different feelings depending on the composition. The areas different colors cover determines the attraction areas on the canvas.

Mondrian achieved the harmony and balance he was looking for by not only the composition technique he used, but also via the proportions of the canvases he used. He mostly worked with square canvases which already create a sense of balance in comparison to rectangular ones (Figure 5.4.1.)[5]

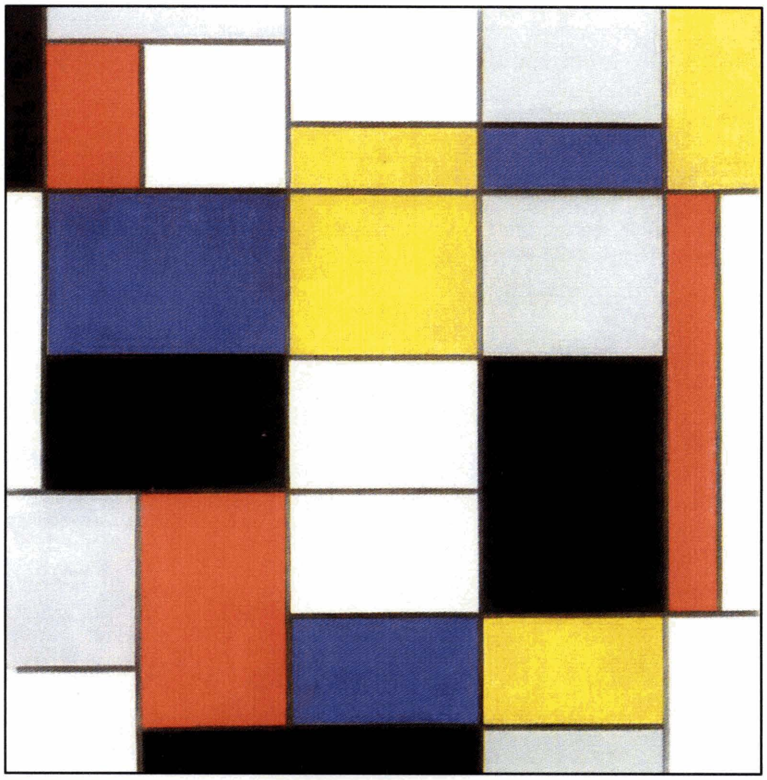


Figure 5.4.1

Composition A by Piet Mondrian, 1923

5.4.1. Rule of Thirds

In the composition of an image, the character of the framing geometry of the two dimensional canvas also has an influence in the way the image is depicted. For instance, unlike the square frames, the rectangular frames create a tension, which happens due to the unequal proportions of the geometry. A rectangular frame automatically creates the feeling of verticality and horizontality, which also evokes the feelings of

[5] Index page
http://www.georgetown.edu/faculty/irvinem/visualarts/Image-Library/Mondrian/ (Accessed May 10, 2006)

directions. The framing lines of a rectangular image plane, perceptually encourages the rectilinear division of the canvas.

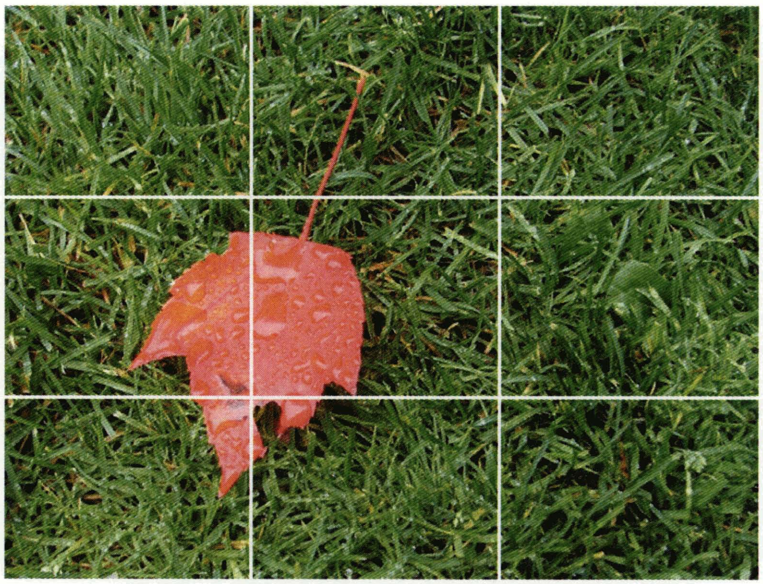


Figure 5.4.1.1

A photograph shot by considering the rule of thirds

Being open to discussion, there are some widely accepted and used composing techniques in photography. For my research, considering the rectangular framing of the images, I focused on rule of thirds. Rule of thirds depends on division of the canvas into three equal regions by use of two vertical and two horizontal equally spaced lines, and use of these lines as the guides of composing. These guidelines and the rectangular regions created by division strengthen the emphasis of the directionality, which comes from the character of the rectangular frame. According to the theory, also the intersection points of the horizontal and vertical lines create the four attraction points which are assumed to evoke stronger feelings when the composed elements are associated with them.

Like many proportional approaches of design, including the golden section and like, the efficiency of thirds rule in creating good compositions is open to discussion. However, this thesis focuses on creation of a modal for digital tools to create desired images via thresholds of quality. Rather than the flawless validity of the rules that will be applied within the modal, the validity of the model is more important.

In this study I will take the thirds rule as a sample for determination of good composing. The main reason behind is that I will be using rectangular frames, which already implies the directions that will work well with the rule of thirds. However, these rules can be implemented according to the considerations of the user.

5.4.2. Light and Photography – Light and Space

As I mentioned earlier, photography is basically capturing the light and its effects. But the techniques for use of light in photography are not trivial. The darkness-brightness balance, contrast, and the tones of grey and their distribution can be counted as some of the many features that effects the characteristic of a photograph. The very basic two illumination types used in photography are the direct and the diffused light. Here I will briefly explain their meaning and effects they create in photographs.

The surfaces or objects subject to direct light from a natural source like sun or an artificial one like a spotlight or projector can be classified as directly lit entities. The direct light draws strong traces when it penetrates through openings and hits surfaces. If it hits objects, it creates harsh shadows. Thus, direct light creates higher contrast with the play of bright and the dark. On the other hand diffused light refers to softer distribution of light, in which the sharp traces of light can hardly be seen. In the diffused light condition, light hits the surfaces and objects after reflecting from the other surfaces it previously bounced. In a diffuse light environment the contrast between bright and dark areas is lower and the environment is mainly characterized by the distribution of mid tones of grey in the environment.

The different types of light distribution in the photographs create different moods and feelings. The intention behind selecting a specific lighting condition depends on the aimed mood that the photographer wants to achieve. The same approach applies to painters, where they carefully articulate the light to depict a specific condition of light with the intended mood.

Dutch painter Johannes Vermeer's (1632–1675) paintings properly illustrate how the aimed mood of environment can be achieved via articulation of light in space. Vermeer, during his living in Delft, mainly created paintings depicting domestic interiors together with some portraits and cityscapes. His compositional settings were close to his contemporaries, however the soft colors he used and the way he depicted light endowed his paintings with more of a quality. The thin loose layers of paint he used on the canvas were the result of his conception of light in space.

The interiors depicted in Vermeer's paintings are characterized by soft tonal changes on surfaces. The figures in the space generally interact with light, which helps in depiction of the depth and the orientation of the space. Moreover, these figures generally are associated with bright objects to balance the general dim mood of the image. The white drawing sheet in front of the figure in 'The Geographer' (1668 - 1669) clearly shows how he overcame dullness that would happen due to use of a narrow band of tones (Figure 5.4.2.1).[6]

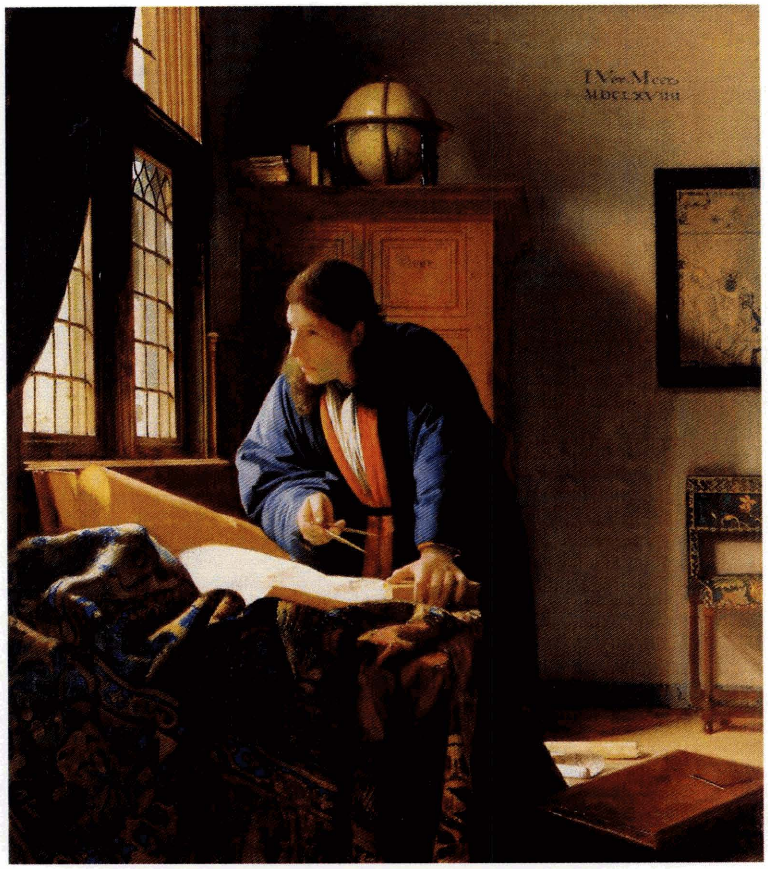


Figure 5.4.2.1.

'The Geographer' by Johannes Vermeer

Similar intentions are existent in architectural design. Architects configure the spaces in the awareness of the effects of light, and the try to create a proper composition, according to their consideration. As well as the balance similar to the case in Vermeer's paintings, a total unbalance can be created intentionally. The imagination related to architectural space, however, can't be easily realized like in photography or painting.

[6] Webmuseum webpage, http://www.ibiblio.org/wm/paint/auth/vermeer/geographer.html, [Accessed May 12, 2006]

Architecture, aiming the creation of the real space, brings multi-layered concerns and complexities related to construction. But on the other hand, the design process may still be manipulated via changes in priorities, and the images can be given greater importance.

An image driven process would be as valid as any other one. This was the idea I came up with, with the motivation I have about working with images, and the availabilities offered by the developing technologies. In the following chapter, first I will explain how an image driven process could work manually and then I will discuss the possibilities of supporting such kind of a process with digital tools.

6. Image Driven Design Processes

6.1 A Manuel Process of Articulating Spaces via Evaluation of Products of Computer Graphics

Architectural representation has always been one of my greatest personal interests. In my undergraduate studies, most of the final presentations I prepared were hand crafted including the architectural drafting and color illustrations in perspective. I started using computer graphics for architectural representation relatively later compared to my colleagues, but then made a quick progress due to my high interest. My technical knowledge about rendering tools developed via research, and the resulting images were evaluated above a certain level of quality. One of my very first animations 'Traverse' took place in 'Unbuilt Monuments' Exhibition of Associate Professor Takehiko Nagakura. The exhibition was sponsored by Massachusetts Institute of Technology and took place in Gallery A4 in Japan between January 2006 and February 2006.

Traverse depicts two different spaces belonging to parallel universes. The initial space gives references to this world, and it can be named as a room, constructed according to rules we already know and accept about the real world. A drop hangs on the edge of a *teapot* on a table. As the drop falls, it transports into a different space, the space of itself where it can travel according to its wish instead of behaving according to the rules of real world, like falling due to gravity. The two different spaces however resemble each other geometrically to prove that they are not totally different entities, at least they were created in the same environment of digital modeling.

This study besides being an enjoyable and satisfactory experimentation evoked many questions in my mind. I was trying to define the way that I built the two spaces. Obviously, it was one of my freest design attempts where I was released from the obligations of Architectural design. But I was still taking design decisions and trying to define the space via restrictions.

After finishing the movie, in the following months, I realized that my previous experience was an image driven design process, in which I was making the decisions according to the images I got from my renderings. I decided to make a quick individual study to understand how an image driven process could work.

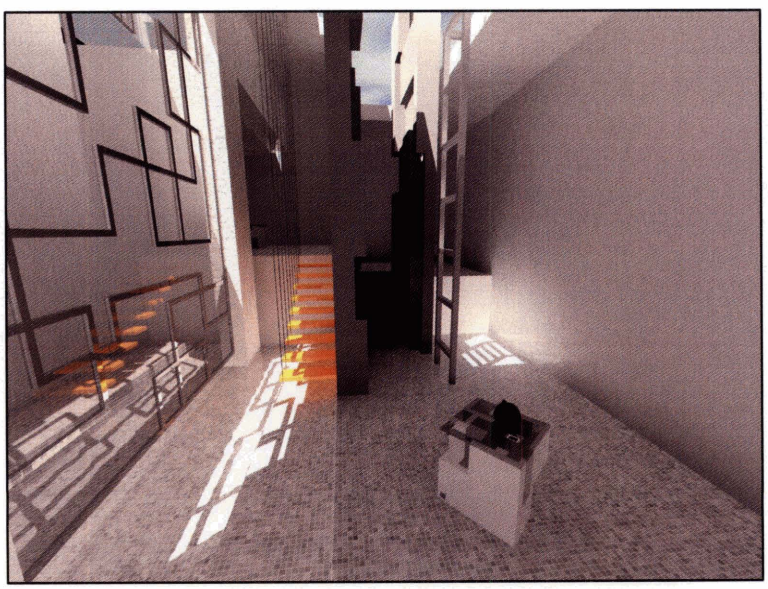


Figure 6.1.1.

Photorealistic animation 'Traverse', primary space

Figure 6.1.2.

Photorealistic animation 'Traverse', secondary space

'A room' was a study that I started working with a simple digital model. There were no pre-set rules that I was in the need of following. The only consideration I had was to try to catch the image in my mind's eye and in the sake of doing that I let myself to do any kind of change in the model itself or in the digital scene to capture the image. I followed the basic sequence that I described in the previous section of Realistic Images and their creation. I build a model with no complex geometry and imported it into3D Max. I decided to include simple objects like a painting on the wall, a piece of furniture and a very low table. I was not sure about using a small pool at the corner of the space. I used Radiosity since I was intending to render many images without changing the lighting setting via many cameras. I picked the daylight system as the appropriate lighting since I wanted the environment to be lit by natural light and articulated by both diffuse and direct light entering from limited number of openings. My aim was to try to catch the tonal quality in the space with minimal articulation of geometry. The interaction of light with the object was also a consideration.

After preparing the setting in 3D Max environment, I started attributing materials to objects and to the surfaces. I adjusted the texture qualities and the colors of each material. Then I started taking renders. My fist consideration was the angle of light penetration so I started playing with the position of the light source, which is called as the daylight system, and the time of the day to determine how inclined the light would penetrate in. Without a determined sequence of actions, I also updated the model, the size of the opening, the location of the objects in the space and so on (Figure 6.1.3.)

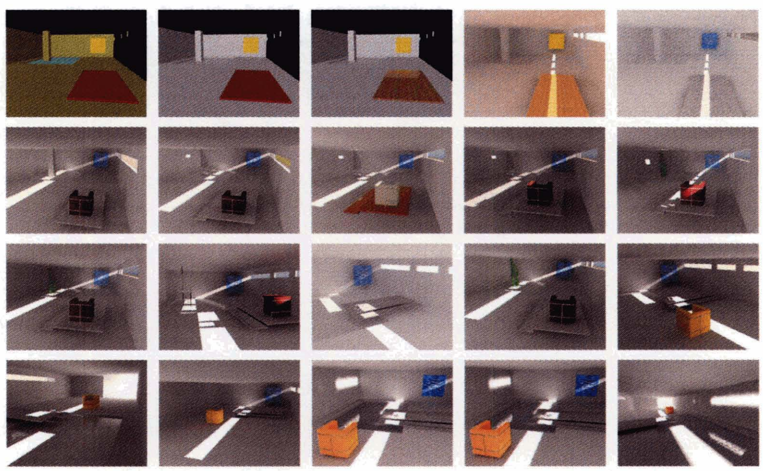


Figure 6.1.3.

Sequential renders of 'A Room'

Sometimes the directions images oriented me was even interesting to me. At the beginning of the study I envisioned a column close to the corner of the room and in the image in my mind it was creating a nice ambiance with the light that would be hitting it at its bottom. While updating the model and the scene I realized that the effect I was looking for not there and that was not happening due to the lack of technical knowledge about the rendering software I was using. I immediately thought that the object I was envisioning in the corner was not necessarily a column but a vertical entity. I replaced it with a statue; I changed the material properties including transparency and colors. I was unable to match the images I was getting from the renders and the one in my mind so I even decided to change one of my initial decisions and created an individual light intake for that specific vertical entity.

Suddenly I realized the last opening I made totally changed the mood and the character of space, and the proximity of the images I was getting via rendering to the image in my mind had been almost destructed. I changed that update and finally removed the statue too. There was no vertical object there; in fact the image in my mind didn't include it in contrast to my thoughts about the space. In the meanwhile, the objects with their materials properties and positions started revealing the perception I was seeking for. Finally I saw an image, which evoked the feelings and perceptions in my mind.

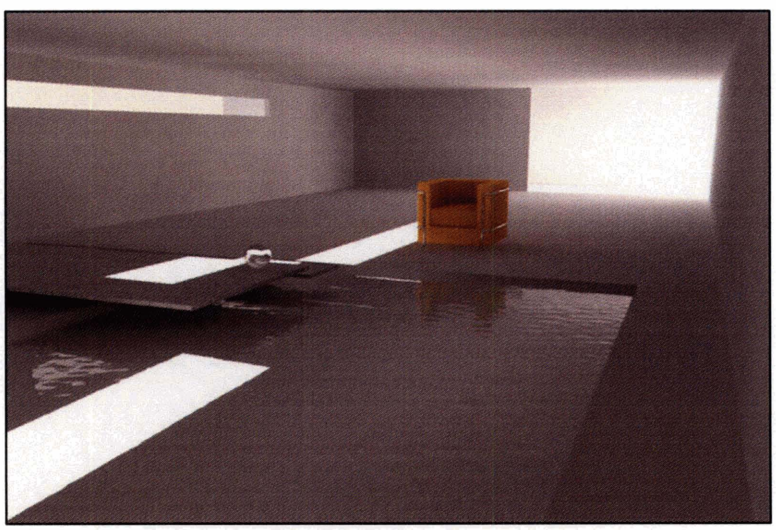


Figure 6.1.4.

Render, 'A Room'

All this process, which ran on the evaluations via seeing was manually processed in technical means. Here, I mention the updates that were made in the model and the scene setting as manually processed actions. I continued the experimental study approximately ten days and I produced over two hundred images. I saved thirty of these images since I thought that they worth doing so. Even some of the se images were very initial ones without any texture mapping, which I saved for describing and documenting the process.

This study on the one hand was an individual proof of possibility of a purely image-driven process. But finally it had no methodology to follow. My motivation shifted towards a effort of better understanding what images introduces and how the intended image could be extracted from a digital model with the help of computational tools.

6.2. Power of Scripting: Generate My Ronchamp

One of the crucial steps I have taken at the beginning of my study was deciding to start working with MaxScript. MaxScript is the built-in object oriented scripting language of 3D Studio Max.

In 3D Studio Max, the graphical user interface (UI) enables the user to give all kinds of commands, but the relationship is one to one. Each command creates one single action by use of user interface. However, scripting enables creation of codes, which store the information for commands in different lines. Regardless of the amount of actions; these can be executed with one single command.

The first study I made with MaxScript was related to configuration rather than the contended. As a starting point I chose Le Corbusier's famous design, the Chapel at Ronchamp.

This chapel was formed in the awareness of the expression by Corbusier himself: 'On the interior, the essential takes the place.' Corbusier clearly knew what he wanted to see in the resulting design, and this intention was revealed by the construction of this building. Corbusier never had a chance to see the realistic renders of his creation; my question was would it make a difference if he had a chance to do so.

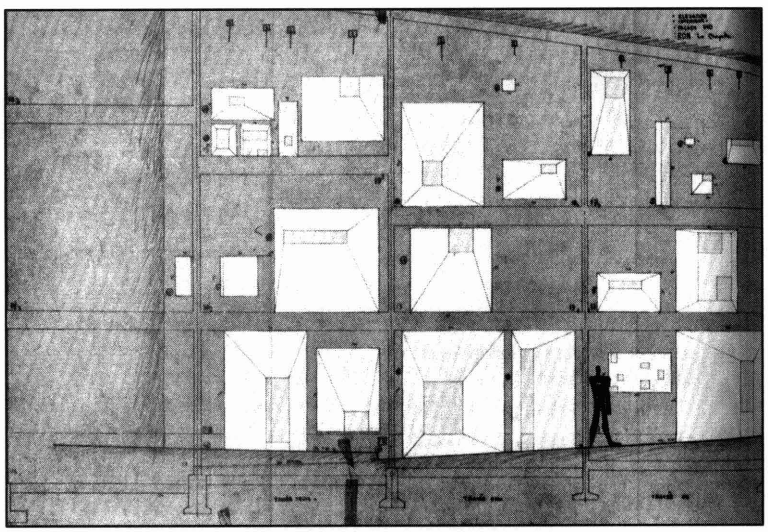


Figure 6.2.1.

Section drawing of the Chapel at Ronchapm by Corbusier

This question was not addressing the mood of the space but it was rather addressing the configuration that was creating that mood. Amongst all the pictures of the chapel I've been looking at, including the ones depicting the dramatic effects of light in the chapel, Corbusier's interior façade drawing was the most crucial one to me (Figure 6.2.1.) This drawing was depicting the *cause* of the other dramatic pictures. It was depicting the system that was revealing the architects intention. The unique light effect, with no doubt is created by the light intakes Corbusier punched out on the tick wall of the chapel.

The way Corbusier concluded the exact configuration of the light intakes became my greatest interest. The windows, keeping their geometrical characteristics could be located in slightly different places, or even same windows could be organized in a totally different way which would end up in creating a very similar effect compared to the actual one. Setting this as a design problem I started working with MaxScript.

My aim was to create a little user interface in 3D Max which would enable the users to create a desired situation via random designs. First, I simplified Corbusier's façade configuration to its simplest state possible and thought it as a wall with rectangular openings.

I scripted a small user interface that takes a wall and a *valuable object* as an input and punches out randomly placed windows depending on the parameters the user selects. The basic parameters for the program I determined are:

1. The number of windows
2. The minimum width of the windows
3. The maximum width of the windows
4. The minimum height of the windows
5. The maximum height of the windows

In create My Ronchamp, the program checks the relationship of the object with direct sunlight and evaluates the amount of light hitting the object in each randomly created condition. I enabled the user to define a threshold for the amount of light that would hit the object. If the resultant amount of that specific case is above the threshold, the program takes this case as a valuable condition. If not, it regards it and creates a new configuration. This continues until the number of variations entered by the user is reached. After the determination of the valuable, the program takes the following actions in a fully automated way:

1. Prepares the Radiosity solution for the valuable situation
2. Renders the image and saves the image file
3. While saving the file it also stores the corresponding value to that specific case as a reference.

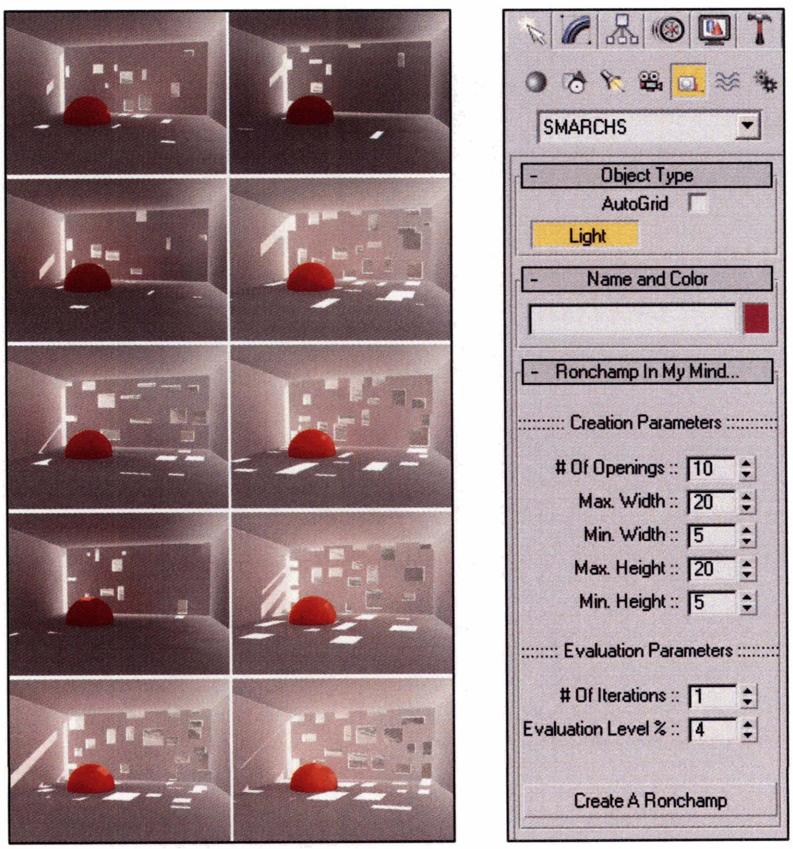


Figure 6.2.2.

The user interface of the plug-in and some outputs of the algorithm

This small plug-in I coded for 3D Max was the first digital tool that was created to work on a specific design problem. This program was the first step I took in establishing ways to define a desired design condition in computational means. The program was successful in some aspects, which can be classified as:

- Creating an automated process: The program is creating random configurations depending on the number of variations entered by user. A wall with twenty random rectangular openings, by using the regular user interface in 3D Studio Max would take from one minute to couple of minutes depending on the experience of the user, whereas the plug-in is able to create at least three walls under one second. The evaluation is also included in this time.
- Evaluation: Program can check the resultant design according to a threshold. It can eliminate the discarded ones and save the valuable ones.

The plug-in also was lacking some important considerations, which I tried to implement in the later studies. The basic missing points were:

- Evaluation: Plug-in was evaluating the light condition only for the determined valuable object, while there was no control for the other sections of the space..
- Point of view in space: The evaluation and the rendering cameras are totally different. The saved valuable image is lacking in giving information about the condition of the light-valuable object relationship.

The outcomes of this study, especially with the missing points that were to be implemented had oriented my research towards this thesis.

7. Proposed Model for Image Creation

7.1 Objectives

This thesis aims to introduce a model which would enable the architects to extract the images from their imaginations of designs, regarding their intentions related to the tonal distribution of light in the space. The model motivates the architects to start working with realistic images at the very beginning of the design process to be able to visually perceive the image in their mind's eye, to run an image-driven design process.

The model is supported with a digital tool, which aims to detect the tonal intention of the architect via reading the images selected by them as well as to render images by using established compositional techniques in photography. The image introduced to the program is read via several algorithms and the tonal qualities it represents are characterized with numerical values. These values are later used as a reference in the creation of the new images. While being flexible, the featured tool uses the rule of thirds in the determination of the composition of the image. Under the following titles, I will explain the way the plug-in works with detailed information about the algorithms it runs.

7.2. The Tool: Narration of Light

7.2.1. Workflow

While embedding complex algorithms, the plug-in aims to present a user friendly user interface for easy access. The plug-in needs two basic inputs to run:

1. The designer selects images, photographs or renders of interior spaces of his or her like in the means of the character of the light qualities in space. The user has to be aware of his or her selection, and the image selected should represent the tones that are admired by the user, or desired for the expected renders. Any image selected for any type of like would not inform the program about the light qualities in the space, which is one of the focal points of the study.

2. The designer creates a sketchy digital model of the space and imports it to 3D Max Environment.

The process:

1. Reading the source image in the means of tonal distribution. This defines various thresholds for the character of the light in the rendered images.

2. Rendering: The plug-in renders the user defined sequence of images to check the compositional quality and the light quality proximity of the captured frames. This is the initial rendering in which smaller

images are rapidly created. All the values are sorted in arrays.

3. Once the sequence is over, the values are checked and the valuable images are rendered in high resolution and are saved.

7.2.2. User Interface

The tool aims to be a demonstrative one due to two reasons: First, current user interface of the plug-in aims an interactive use rather than an automated one for introduction of the model of Narration of Light with embedded algorithms. Second, the tool aims to be open to development, rather than being a finished product.

The features of the plug-in are grouped under three dialog box groups, two of which are totally implemented. The last group presents the features related to automating the process, which will be implemented with the continuing research. The three titles are:

1. Tonal Gradation: This group contains the buttons for introducing the source image to the plug-in. The interface displays the image as a thumbnail and its corresponding value calculated by algorithms. The group 'extras' includes the choices to represent the way of the algorithms work in a graphical manner. The rendered image is also displayed as a thumbnail and the tonal its tonal gradation value is compared to the source image.

2. Composition Element Recognition: The very dark and very bright areas that are influencing the image canvas are recognized and differentiated by the help of the commands in this dialog box. After processing the rendered image, the elements of composition are displayed with the mask of rule of thirds as thumbnails. A corresponding percentage value is displayed for the success of image. The evaluation can be re-done by changing the thresholds for dark and bright pixels.

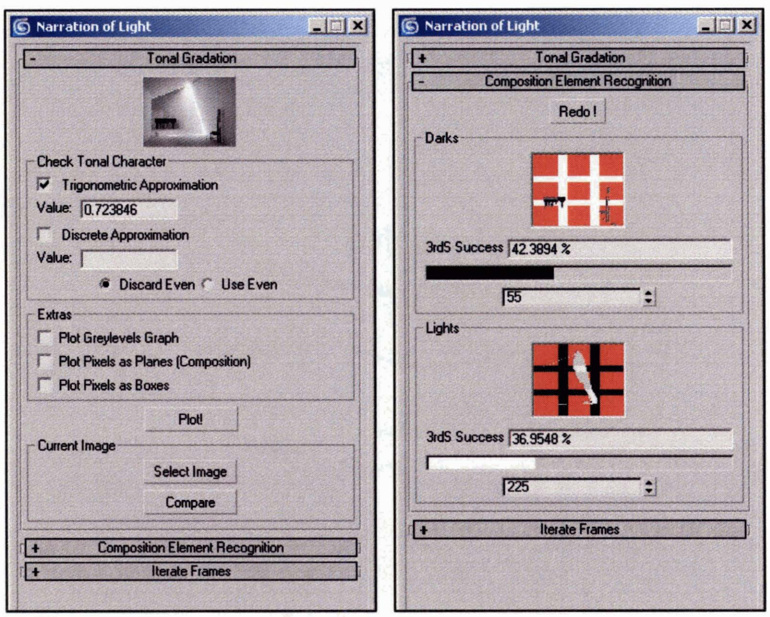


Figure 7.2.2.1.

The user interface of the demonstrative plug-in

3. Iterate Frames: In this partially developed section, the 'Settings' group is used for inputting the borders of the digital model prepared by the user and the number of frames desired to be rendered. Composition Elements group, which will be developed shortly, will offer optional selections for compositional elements. This will help the user to pre-determine the elements to be regarded as valuable objects and arranged in the composition beforehand. 'Finalize

Images' groups will be used for inputting the directory for the images to be saved.

7.3 Image Evaluation

The need for a rendering environment with a level of recognition drove the path of this study into a heavy load of image processing. As well as using the established methodologies and tools, I also went into some experimentation for reading the light qualities embedded in an image. In the following paragraphs, starting with the very basic paths I followed in making the program read the images, I will also explain the complex algorithms I came up with for proposition of a way of evaluating the images.

7.3.1. Step 1: Reading the images via Pixels

3D Studio Max, like the basic primitives it features, recognizes bitmaps as objects. A bitmap, which is a type of digital image type, is a data structure which is composed of array of pixels. Each pixel carries different values to determine their different features, one of which determines its color. The color of a pixel is determined by formulation of its Red, Green and Blue values, which is called RGB.

3D Studio Max can use the bitmaps that are existent in the memory as well as storing them temporarily. It can do the basic applications of saving and opening the bitmaps, too. The *getPixels* command in MaxScript can access to the addressed pixel and get all the information available about that specific pixel, like RGB value or pixel aspect ratio. By creating loops, all the bitmap can be read as an array, and all the pixels of an image can be accessed separately. This makes the program to extract all the information related to a pixel and store it in the memory if needed.

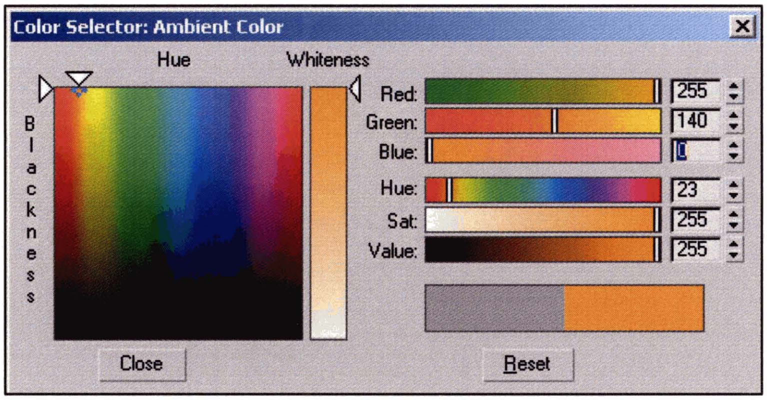


Figure 7.3.1.1.

The diffuse color dialog box in 3d Studio Max The values Red: 255, Green:140 and Blue:0 results in the orange color

In the effort of trying to read the tonal distribution in an image, the basic concern was to read how bright or dark a pixel was. The brightness of a pixel is determined by its grey level value, which is derived via approximation of its RGB values. The grey level of a pixel corresponds to a value between 0 and 255, like the RGB values. In this scale, 0 indicates black, and 255, white. The integers in the scale between 0 and 255 are called as mid-tones and they refer to different tones of grey.

As the first step in building the plug-in, I coded the algorithm to access to all the pixels of an image, and calculate their grey level value via using the RGB values embedded in them. To illustrate the way program worked, I took one of Vermeer's paintings, 'A Woman Holding A Balance', and I added a script to the program to convert all the pixel values into boxes and locate them in the three dimensional environment taking the pixel locations in the original image. The height and the color of the boxes were determined by the grey level value of the corresponding pixel. This little program was the proof of reading the images via pixels, and reading the brightness of each pixel together with its location. Later, I used this information to build the Grey Levels Histogram and other algorithms to determine the light distribution in the images,

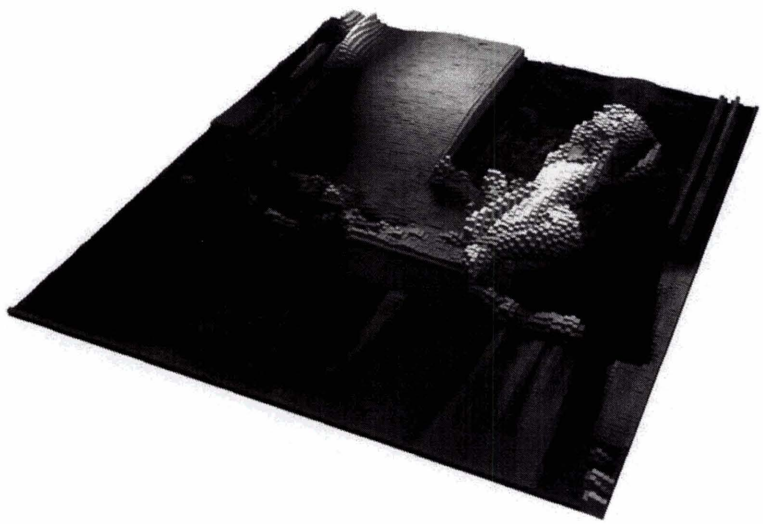


Figure 7.3.1.2.

Vermeer's 'A Woman Holding A Balance' represented as boxes in 3D Studio Max environment

7.3.2. Step 2: Grey Levels Histogram

The grey level histogram of an image, which is the graphical display of the frequency distribution of brightness of the pixels in an image, can be build by derivation of the individual grey level values of all the pixels of that specific image. Adobe Photoshop features the Levels dialog box, which directly outputs this graph. In the grey level histogram, the horizontal axis indicates the grey level values in the scale from 0 to 255, while

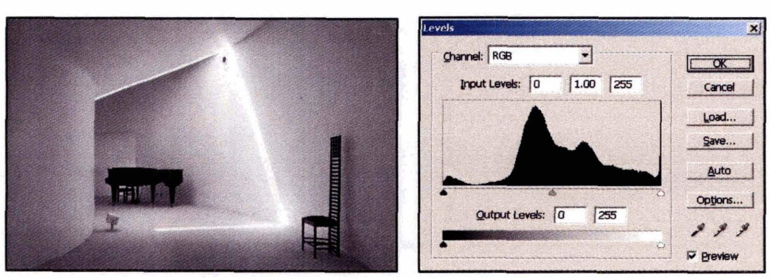


Figure 7.3.2.1.

The photograph of White U by Toyo Ito and the grey levels histogram from Adobe Photoshop the vertical axis indicates the comparative number of pixels attributed to that specific level of grey.

Since the grey level histogram gives the information about the numbers of darker or brighter grey values, if the graph bars are getting higher on the right side of the histogram, it means that it is comparatively a brighter image in the global sense. On the contrary, the bars getting denser on the left hand side of the histogram indicate a darker image. As an illustration, Vermeer paintings gives a result closer to latter since the images depict diffusely lit spaces which don't feature very bright traces of light (Figure 7.3.2.2.) The comparison of grey level histograms of different images would give an idea about the meaning of the diagram.

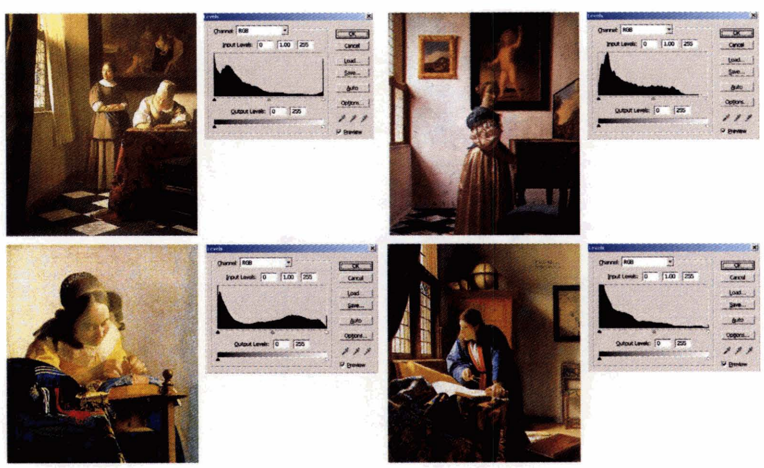


Figure 7.3.2.2.

Some of Vermeer's paintings and their grey levels histograms

The grey level histogram is useful in determination of the global brightness value of an image, however while transforming the information taken from each pixel to the histogram, some information is lost like the distribution of the individual pixels. Since the histogram is just giving the number of pixels, rearrangement of the same pixels, which would make no sense visually would give the same histogram as an output. But the different ways of reading the histogram gives different types of information.

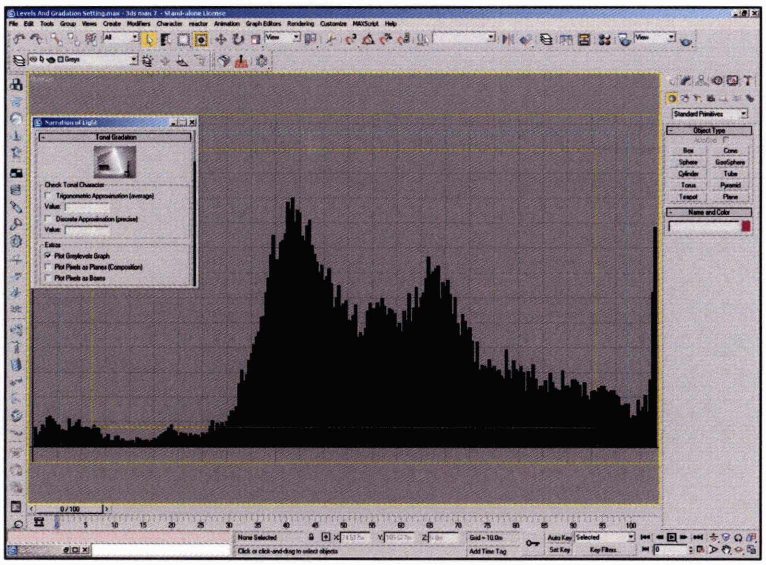


Figure 7.3.2.3.

Grey levels histogram plotted by the plug-in in 3D Studio Max environment

To make a better use of the information about the grey levels of the pixels, I intended to enhance the plug-in and I coded an addition to represent the grey level histogram of the images 3D Studio Max was reading. I made the plug-in plot the graph bars as planes and rendered the scene (Figure 7.3.2.3.) The graphs were 100% the same when compared to the output of the levels histogram of Adobe Photoshop. The algorithm worked perfectly and it enabled me to propose a possible way to make 3D Studio Max aware about what it is rendering to some extend, at least in the means of global brightness of the image. By on-the-fly checking of the grey levels, program was unable to evaluate what kind of an image it was rendering in the means of tonal distributions.

7.3.3. Application of Rule of Thirds by using Levels Histogram:

In the algorithm, the information embedded in the two ends of the levels histogram helps to determine the compositional elements in the scene. Reading the right hand side of the grey levels histogram enables the plug-in to detect the direct light entering the space, and the location of the trace it cerates. The left hand side on the other side reveals the dark sections on the image canvas, which are recognized as compositional elements. The results of the initial tests I made with the image of White U represent how the traces of light and the objects are recognized and categorized (Figure 7.3.3.1.)

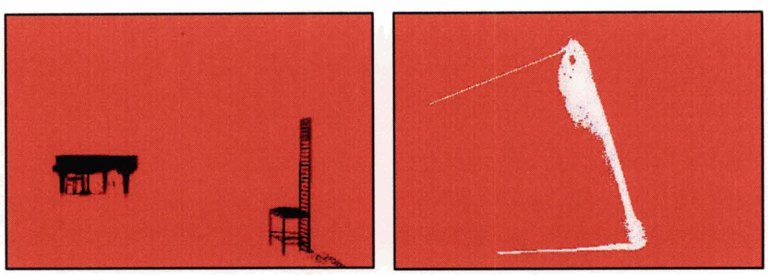


Figure 7.3.3.1.

The outputs taken by reading the different ends of the grey level histogram

While the 'getPixels' command in 3D Studio Max reads the existent array of pixels, the 'setPixels' command updates, changes and re-writes the features of the pixels. By use of this command, to clearly detect the compositional areas in the image canvas, to be evaluated with other algorithms, I discarded the mid-tones of the image. To represent the way program perceives the elements I converted the discarded pixels of the image into red by bumping the Red value to 255 and setting the Green and Blue values to 0. I used the setPixels command to convert the mid-tone area into red and I saved the files by using the Bitmap properties of 3D Studio Max. The resulting images clearly represented the areas to be defined and on the next step I tried to determine a way to evaluate the resulting valuable areas according to rule of thirds.

After the valuable areas, in other words the groups of valuable pixels within the frame were already determined; I intended to check their correspondence to the rule of thirds. To do so, I created the specific bands that divided the canvas into three equally spaced surfaces both vertically and horizontally. To indicate these bands, I converted the corresponding pixels to white or black. The proportion of the valuable pixels overlapping with the bands to the total number of valuable pixels gave how much the image was fitting in the frame determined by thirds rule.

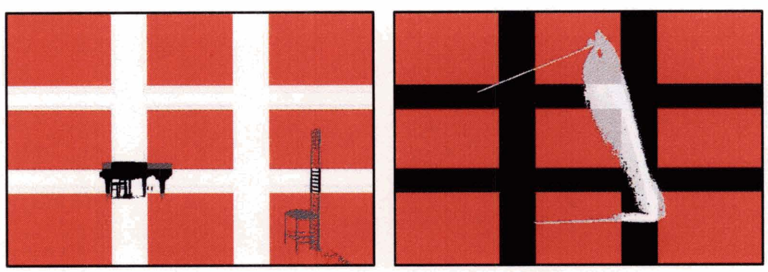


Figure 7.3.3.2.

The masks for checking the value with rule of thirds

The intend behind making the program to determine the thirds rule separately for the dark and bright ends depending on the levels histogram is to give the user the availability of choosing to use either or both at the same time for determination of the rule of thirds value. So the user is able to pick the light trace as a compositional element or not, and same applies for the dark objects or shadows in the scene.

7.3.4. Detecting the Global Light Distribution

As spoken previously, the tones of light in a space, when represented with an image are encoded in the mid-tones of grey. Concentrating on the two ends of the grey level histogram is beneficiary for outputting the composition elements for evaluation with rule of thirds. However, when the intention is the determination of the character of the mid-tone distribution, the histogram can not supply any information other than the quantity of the pixels corresponding to the mid-tones of grey.

In the experimentation of reading the tonal distribution, I tried to read the image as we see it; by trying to establish a way to understand how dramatically the mid tones of grey change and what kinds of gradient they create. Experimenting with some source images regarding such kind of a character of the tones helped in the development of the study. Visually, these images represent specific characters which made them to be easily classified dull, dramatic, and so on but it was a challenge to define these terms computationally.

Several studies I made focusing on the mid range of the grey levels histogram didn't give any valuable result. The reason behind that was the information loss that was happening during the process of creation of the grey levels. I was in the need of reading the image itself, the changes of the grey tones with reference to each other. In other words, I was aiming to find out and evaluate the change in the grey levels through the image frame, instead of the individual grey level value of the pixels. What I was looking for was the deviation of the values rather than the value itself.

I coded two different algorithms to understand the global tonal distribution in an image by checking the local deviations in the grey levels. The first algorithm was totally my experimental development, while in the second one I used some discrete approximations which are used in edge detection in image processing. I will explain these two different approaches and discuss about the results under the following titles.

7.3.4.1. Trigonometric Approximation

In this approach I coded an algorithm to read the images in horizontal and vertical lines. While moving from left to right or top the bottom on the canvas, I took the grey level values of the pixels with getPixels command and compared the change between these values. I created an extra algorithm to plot a graph to represent the numerical values. In the graph the horizontal axis indicates the corresponding axis of the image plane, which is giving the number of corresponding pixels on the horizontal direction, whereas the vertical axis gives the grey level value of the corresponding pixel on the horizontal axis.

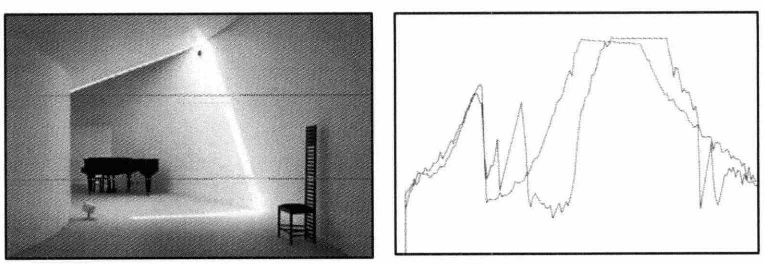


Figure 7.3.4.1.1.

Two pixel lines read on the image and the plot created in 3D Studio Max to show the grey level deviation

The results of first attempts in using the new algorithm ended up in representing extreme deviations and noises, which made it difficult to make the program to evaluate the image in the means of tones. In the second step, I embedded a parameter, which can be adjusted depending on the character of

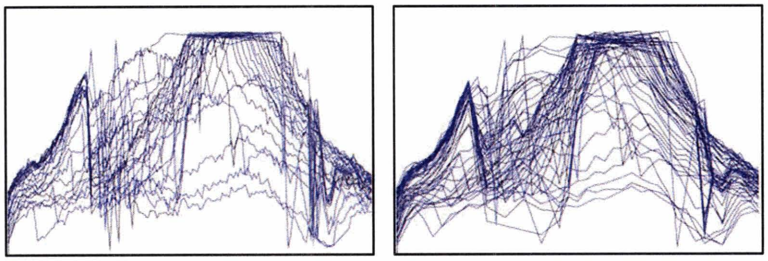


Figure 7.3.4.1.2.

Plots created in 3D Studio Max from the White U image. In the image on the right, noise reduced for precision in evaluation

the image, to read the pixels periodically to take local results about the deviation in tones. In the second step, I created a second parameter to determine the number of pixel lines to be read. Again, depending on the tonal character of the image different number of lines gave more precise results. One another concern about these plots was the extreme changes of the graph where the line was suddenly passing over a dark area next to a very light area. In fact this was the information which I was using for determination of the compositional elements. I excluded such kind of changes from the graph to get the global tonality of the grey tones rather than the sudden contrasts created in the space.

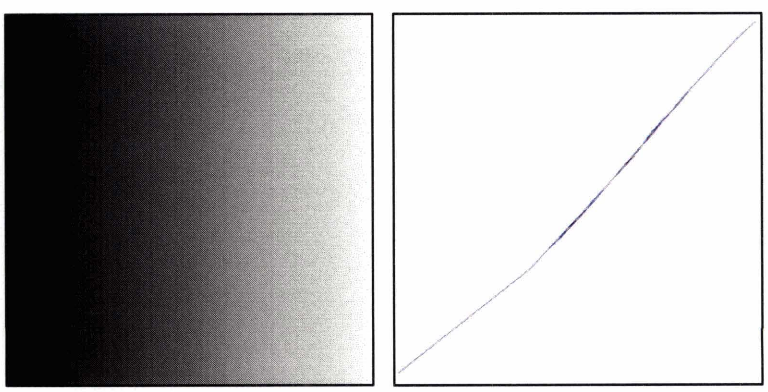
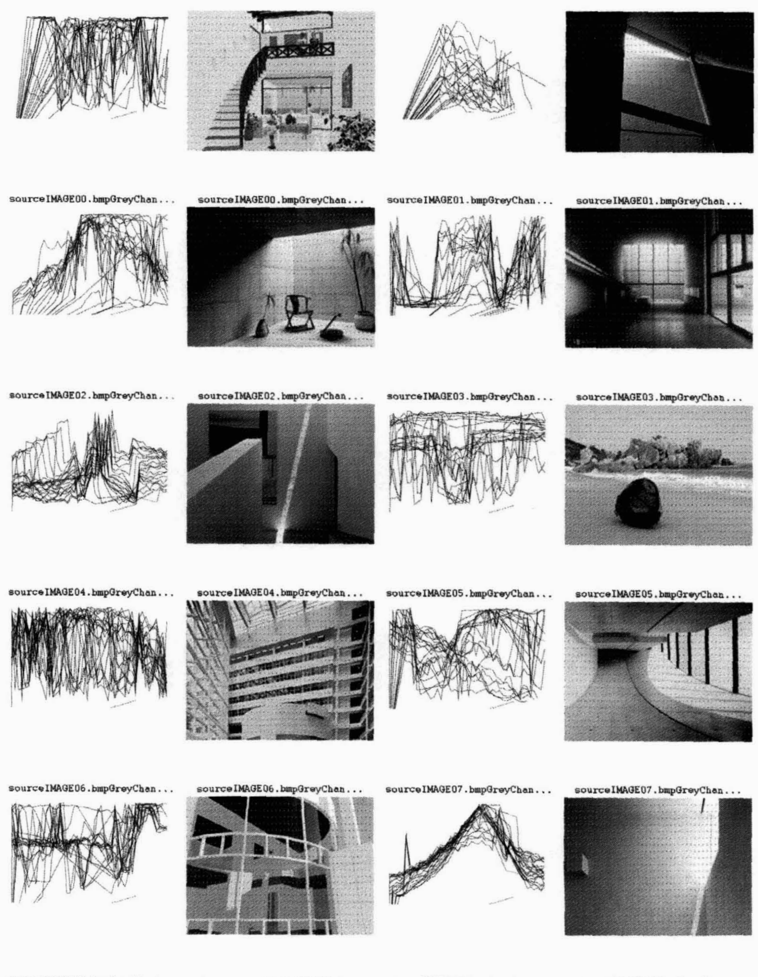


Figure 7.3.4.1.3.

An un-cut full gradient and its trigonometric approximation graph created by the plug-in

In the evaluation phase I intended to use the graphs plotted by use of trigonometric equations. Here, I took a perfect gradient as a reference. The un-cut full gradient gave a curve with an approximate slope of 1. In other words, the angle between the horizontal and vertical axes of the graph was 45 degrees (Figure 7.3.4.1.3.)

By taking the sin value of the angle plotted by the graph, I was able to define a value range for the deviation of grey levels. I applied the trigonometric equation to all parts of the graphs plotted by the plug-in to achieve a global evaluation depending on the local conditions.



<u>Figure 7.3.4.1.4.</u>

Some reference images and the resultant plots for trigonometric approximations.

Trigonometric approach enabled me to make the plug-in output a global approximate value for the tonal change; however more algorithms were needed to create a better evaluation system for the plug-in to determine the tonal character of he images.

7.3.4.2. Evaluation of Local Characteristics: Nevatia - Babu Compass

Nevatia-Babu Compass is a numerical table which is used for edge detection in image processing. The table is used in calculating the deviation of grey levels of pixels in a five by five pixel area. The cells of the table contain integers varying between -100 and 100, and for the calculation of deviation over a specific pixel, the table is placed on the five by five pixel area, centering that pixel. The sum of the product of these specific numbers with the corresponding grey levels of the underlying pixels gives the derivative for the central pixel. If there is a sudden change in the grey levels of the pixels, this area is marked as an edge depending on the derivative value. For edge detection, depending

-100	-100	0	100	100
-100	-100	0	100	100
-100	-100	0	100	100
-100	-100	0	100	100
-100	-100	0	100	100

0^0

-100	-32	100	100	100
-100	-78	92	100	100
-100	-100	0	100	100
-100	-100	-92	78	100
-100	-100	-100	-32	100

30^0

100	-100	100	100	100
-32	78	100	100	100
-100	-92	0	92	100
-100	-100	-100	-78	32
-100	-100	-100	-100	-100

60^0

100	100	100	100	100
100	100	100	100	100
0	0	0	0	0
-100	-100	-100	-100	-100
-100	-100	-100	-100	-100

90^0

100	100	100	100	100
100	100	100	78	-32
100	92	0	-92	-100
32	-78	-100	-100	-100
-100	-100	-100	-100	-100

120^0

100	100	100	32	-100
100	100	92	-78	-100
100	100	0	-100	-100
-100	78	-92	-100	-100
-100	-32	-100	-100	-100

150^0

Figure 7.3.4.2.1.

Compass gradients for different orientations of Nevatia-Babu compass on the global grey level value deviations of the image, a specific threshold is used for marking the edges.

Nevatia-Babu compass features six different tables with different tabulated numbers to find the grey deviations in different directions on the image canvas. These six tables are used in finding the deviation values for per thirty degrees rotation starting at zero degrees, which is the horizontal for the image plane.

The technique is used in many areas, one of which is detection of shorelines from the satellite pictures. In this use, technically, the compass finds the areas where the homogeneous deviation of the pixels corresponding to the sea suddenly meets the pixels of the land.

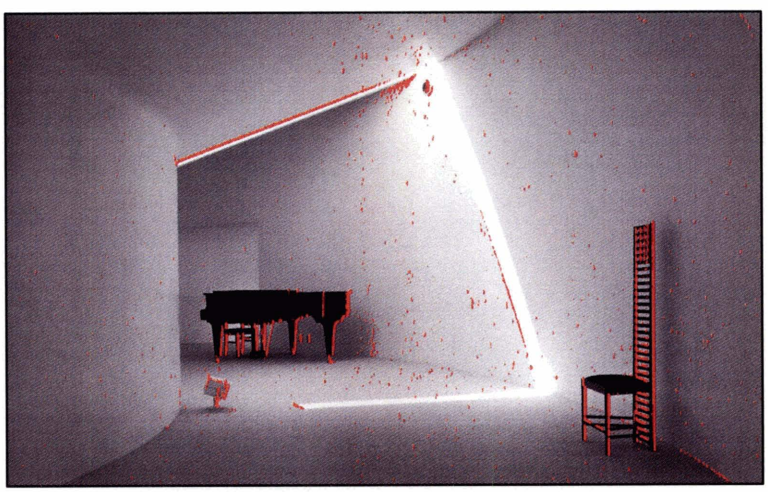


Figure 7.3.4.2.2.

High deviations detected in the White U image, horizontal only.

In the intent of reading the light distribution in the images, I used the Nevati-Babu Compass for two purposes, one of which is the regular use of edge detection, whereas the second one is an experimental implementation of mine, with which I aimed to store the local grey level changes of the images in an array to reach a conclusion about the global light distribution with later evaluation.

Since the purpose of the program is finding the global mood of the image by recognition of the grey level distribution, the edge detection algorithm is used to exclude the extreme deviations which happen around the areas of highest contrast on the image canvas. The six tables I used in the algorithm finds the extreme deviations in all directions on the image canvas. To see the results while developing the program, I marked the pixels resulting in high deviation with different colors depending on the direction of the Nevatia-Babu Compass. In the next step I used these marked pixels for the evaluation of the image in the means of noise. With an additional equation, I made the program to reduce the value of an image in case of a high-noise condition.

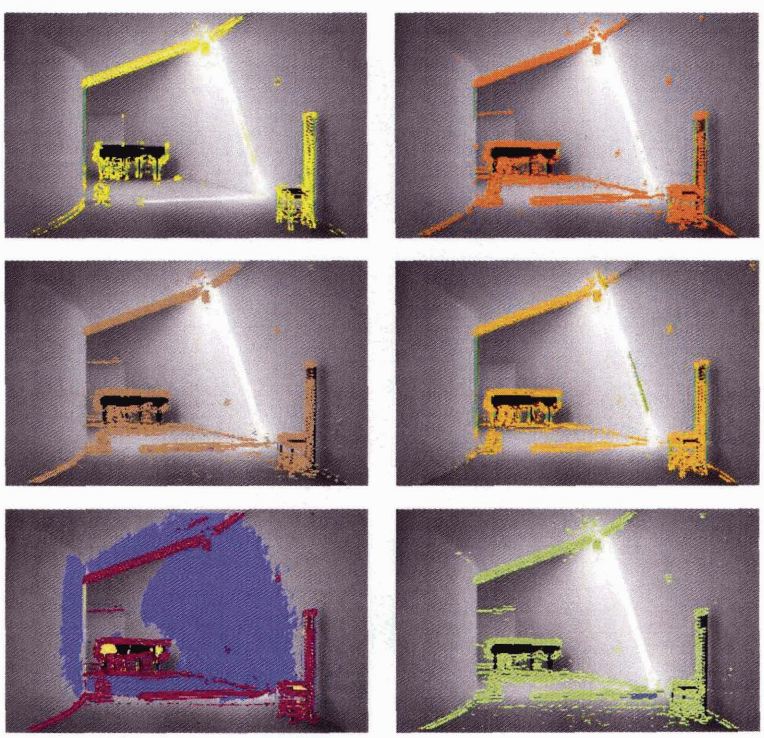


Figure 7.3.4.2.2.

High deviations detected in the White U image, all orientations. Low deviations and noise locations area also marked and stored.

The method I used for the purpose of excluding the high contrast passes from the evaluation of the grey distribution was a modified version of the established methodology of the Nevatia-Babu Compass. However, the second use was a more individual method where I used the calculations with the compass to determine some local conditions of the image.

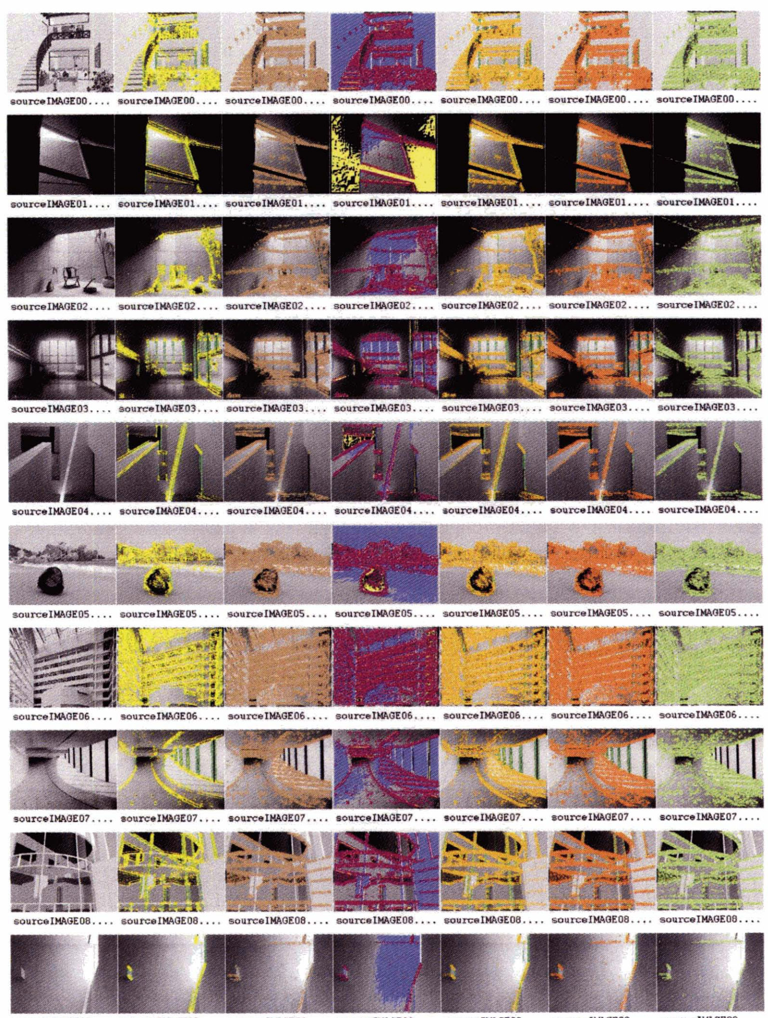


Figure 7.3.4.2.3.

Results taken from the application of the Nevatia-Babu compass algorithm to the source images. The outputs help to define the grey deviations in the images and classify them according to their characteristics

The second algorithm aims to detect the darkest and brightest dull areas in the image. In other words, the program tries to recognize the areas, on which the grey level deviation is minimal. The reason here to look for dark and bright areas is to avoid misevaluating some images which has small deviations on the very dark and very bright ends, but still are interesting. For instance, one single window in the middle of a large wall, with a bright daylight outside would end up giving a photograph which includes a large amount of dark pixels with very small deviation, however it can still be considered as a good image for the user, or it can be the intention.

7.4. Results

The theoretical side of this thesis developed simultaneously with the practical one. It was one of my greatest considerations to generate and test the algorithms that would support the ideas and theories. The plug-in, still being open to further development and implementation, matured enough to run a demonstrative process for selection of the images depending on the tonal intentions of the designer.

At the beginning of the thesis, I briefly talked about different types of the research I made, which motivated me to drive the thesis to the direction it was developed. One of those was the individual study which I called as 'A Room', which was a manual process of image generation and evaluation via seeing. After the development of the digital tool I worked on, I preferred to test it with the images of an environment I was familiar with.

I started the process by defining camera paths for creation of a sequence. This time, since the program was going to evaluate the images, I was not supposed to repeat all the actions in front of the computer that I had been doing in the previous study. Finally, I left the computer to render the sequence of two thousand images to be evaluated later on.

The reference images I have been using while testing the algorithms in the development phase became a very valuable source for the final part of the study, since I already had a strong visual experience on them and since I tested the outcomes of the algorithms by using them over and over again. My aim was to give these reference images one by one as the source of the tonal intention of the designer and see the variation of the outcomes from the same model regarding the different reference images. The rule of thirds was also ready to run with the mask of parallel bands for the evaluation of the compositional setting in the renders of 'A Room'.

The plug-in worked smoothly and after couple of hours, the images were classified and sorted according to the reference image and the compositional evaluations. In the following pages, fist I will present sample images that were arbitrarily chosen for the demonstration of the results taken from the algorithm. Later you will see the images plug-in selected depending on the different references.

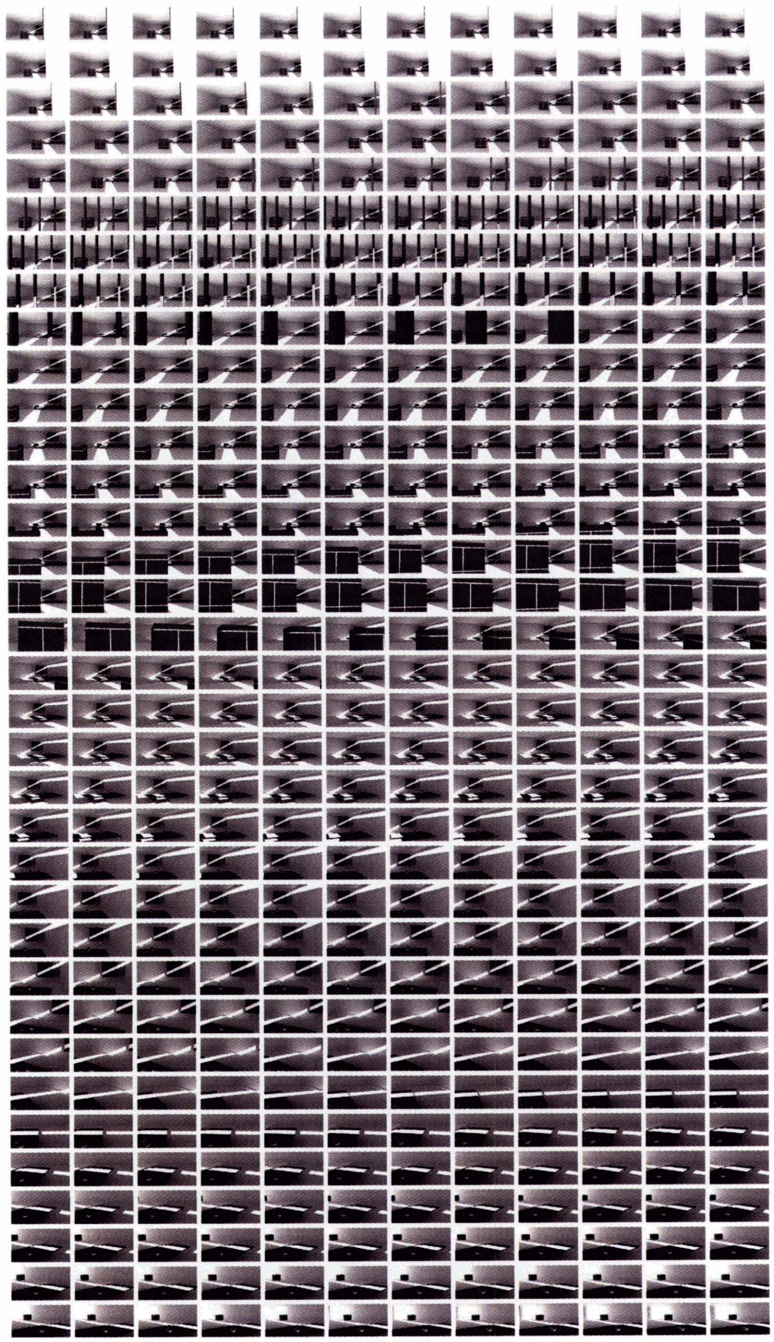


Figure 7.4.1.

Beginning portion of the final sequence rendered in the digital model of 'A Room'

7.4.1. The Process of Image Evaluation

The application of trigonometric approximations revealed the global tonal character of the images from the sequence. The images and plots generated by 3D Studio Max (Figure 7.4.2.) demonstrates a basic check on the images, whereas the final controls were made by reading all pixel lines of the images for a more precise result. The changes in the slope of the line diagrams show the deviations between the consecutive reference pixels on the image canvas.

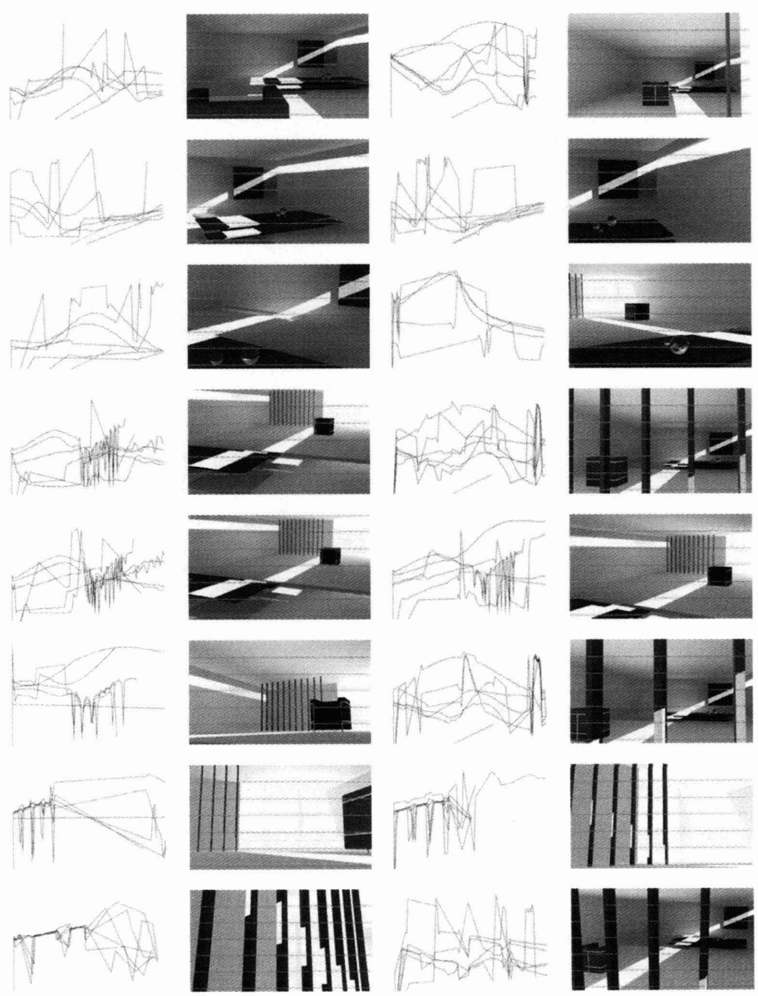


Figure 7.4.2.

Some images from the final render sequence and the basic resultant plots for trigonometric approximations. Each diagram refers to the image on its right.

The Nevatia-Babu Compass algorithm was applied to the images simultaneously with the trigonometric approximation algorithms. The outcomes were used in determination of the proximity of the rendered image to the reference image in the means of the global grey deviations as well as the resemblance in the dull areas where the deviation is below a threshold.

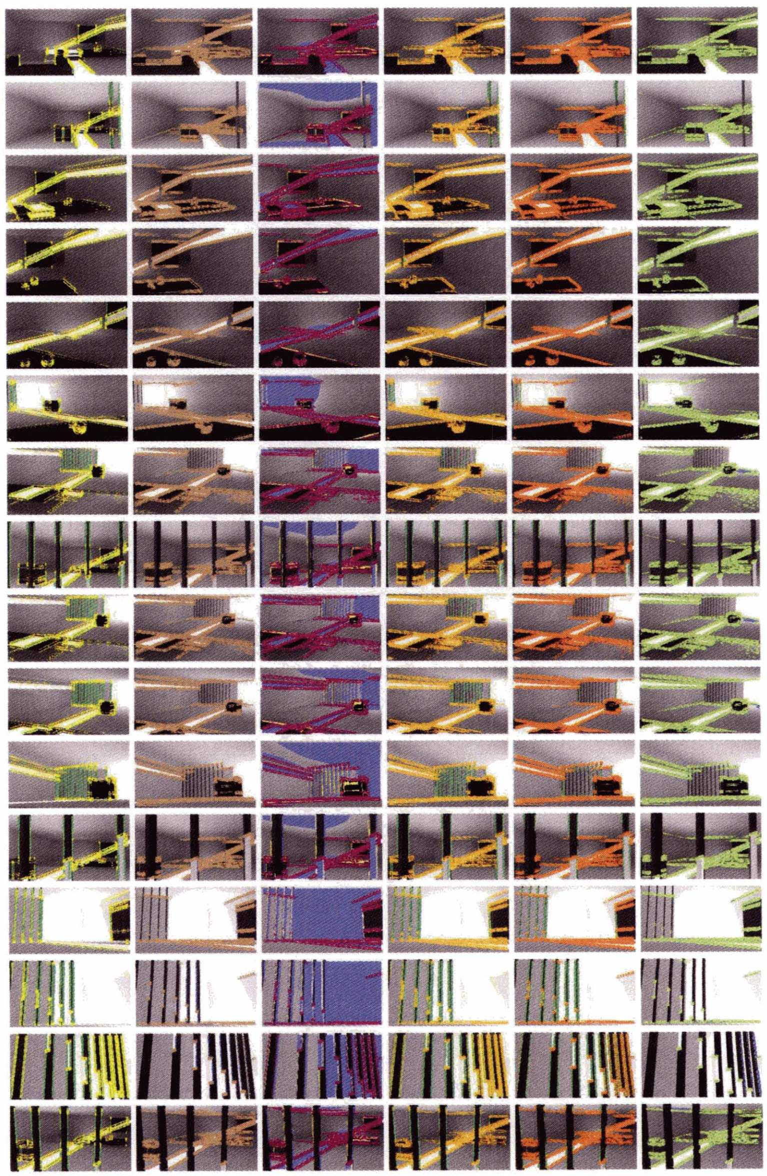


Figure 7.4.3.

The outputs from the Nevatia-babu compass algorithm for some images from the final render sequence

The rule of thirds algorithm was applied to all images of the sequence separately. The images were evaluated and ranked with percentage of success. Application of the algorithm for both bright and dark pixels enabled three different evaluations dependant on either the dark objects or the traces of light, or both in the compositional meanings.

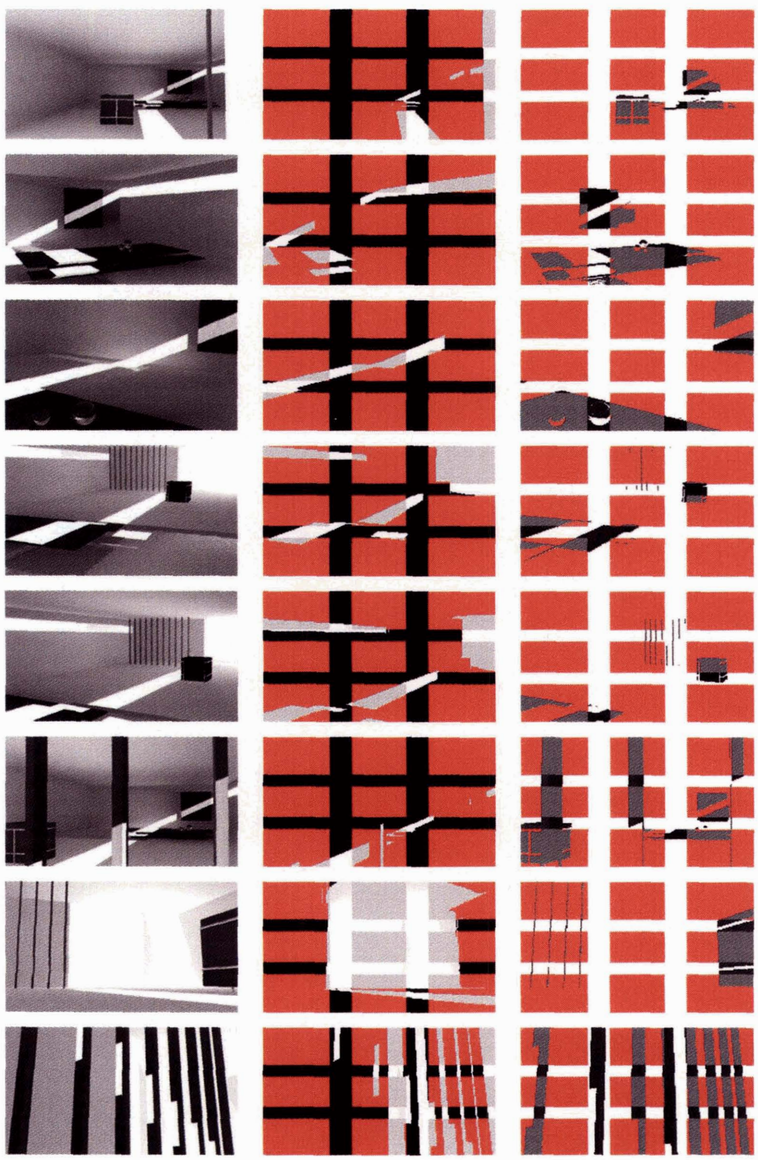


Figure 7.4.4.

The evaluation images created by the rule of thirds algorithm

While the program was generating the numerical values for the image evaluation, I also printed the outputs for documentation for later referencing. The numerical output, when sorted in an excel sheet clearly showed the order in which the images were selected by the program.

IMAGE	TRIG 2 LINES	TRIG 7 LINES	Trig 20 lines	TRIGort	IMAGE	BABU 0 only	BABU (noise exclusion)	BABU (null exclusion)	Thirds Darks	Thirds Lights
0	0.63759			0.63759	6	4471.96	24.3652	363.47	56.87%	37.15%
1	0.685592			0.685592	46	3998.45	18.872	392.646	56.62%	37.12%
2	0.694145	0.671061	0.687486	0.684231	51	3889	18.5513	408.099	44.45%	37.11%
3	0.645648	0.645265	0.709547	0.66682	47	3888.46	15.8236	474.127	44.14%	36.93%
4	0.584478	0.603107	0.684752	0.624112	48	3865.3	14.3311	573.931	43.63%	36.88%
5	0.504706	0.611435	0.585795	0.567312	50	3855.58	13.8382	610.233	43.37%	36.66%
6	0.62393	0.61512	0.651139	0.630063	7	3849.69	11.5832	633.204	39.40%	36.64%
7	0.641073	0.634758	0.578453	0.618095	49	3813.78	11.316	643.916	36.77%	36.47%
8	0.619683	0.565461	0.618408	0.601184	45	3736	9.59654	651.076	36.75%	36.32%
9	0.583246	0.52655	0.583197	0.564331	99	3675.87	9.27498	652.82	36.72%	36.31%
10	0.560307	0.559438	0.524904	0.548216	53	3673.69	8.50892	668.703	36.49%	36.17%
11	0.516099	0.474591	0.497375	0.496022	44	3647.73	7.50226	673.257	36.42%	36.07%
12	0.538491	0.540354	0.467821	0.515555	5	3627.88	6.95039	683.069	36.32%	35.98%
13	0.505424	0.530864	0.506602	0.514297	52	3615.96	6.76111	684.366	36.15%	35.98%
14	0.516682	0.522314	0.563312	0.534103	8	3537.57	6.27078	699.408	36.02%	35.92%
15	0.496614	0.540796	0.569284	0.535565	64	3490.77	4.95455	702.043	35.80%	35.92%
16	0.513215	0.576639	0.611138	0.566997	98	3489.78	4.51092	728.962	35.80%	35.78%
17	0.420104	0.571766	0.586167	0.526012	65	3429.52	4.40151	730.452	35.50%	35.68%
18	0.519075	0.578788	0.605075	0.567646	66	3410.37	4.38249	746.688	35.43%	35.67%
19	0.517685	0.540055	0.535218	0.530986	54	3383.89	4.38104	757.752	35.28%	35.67%
20	0.526536	0.476813	0.539869	0.514406	52	3346.74	4.26166	759.127	35.08%	35.63%
21	0.528479	0.510491	0.51277	0.517247	55	3290.64	4.1215	764.5	35.01%	35.63%
22	0.495147	0.48825	0.529985	0.504461	62	3280.5	3.94156	768.328	34.98%	35.63%
23	0.552192	0.546122	0.476126	0.524813	71	3270.54	3.90796	775.763	34.87%	35.63%
24	0.535808	0.514161	0.48738	0.51245	72	3224.96	3.8853	793.871	34.78%	35.61%
25	0.514091	0.532071	0.507647	0.517936	43	3214.59	3.86215	800.684	34.77%	35.57%
26	0.531813	0.508941	0.528482	0.523079	65	3202.61	3.85978	802.683	34.76%	35.57%
27	0.544729	0.521066	0.55252	0.539438	93	3192.35	3.83797	808.516	34.76%	35.57%
28	0.53792	0.545522	0.535113	0.539518	73	3177.16	3.83231	822.423	34.76%	35.55%
29	0.491315	0.541572	0.526822	0.519903	75	3166.25	3.80999	826.953	34.76%	35.54%
30	0.456865	0.496805	0.48716	0.480277	91	3145.07	3.72757	829.534	34.72%	35.54%
31	0.4398	0.499547	0.484992	0.47478	68	3133.34	3.72549	830.208	34.67%	35.53%
32	0.433245	0.46082	0.502946	0.46567	61	3124.13	3.6977	842.105	34.66%	35.49%
33	0.451035	0.46498	0.371338	0.429118	89	3109.76	3.60344	865.199	34.66%	35.40%
34	0.381114	0.274838	0.186745	0.280899	60	3062.25	3.58562	879.051	34.64%	35.35%
35	0.485782	0.334406	0.257514	0.359234	56	3050.25	3.54342	883.48	34.60%	35.34%
36	0.457256	0.384594	0.370888	0.404246	74	3036.32	3.50949	894.501	34.58%	35.22%
37	0.428739	0.402061	0.418783	0.416528	57	3012.85	3.45898	898.743	34.56%	35.22%
38	0.457378	0.464882	0.436263	0.452841	70	2951.9	3.44761	901.023	34.48%	35.17%
39	0.439408	0.510168	0.492873	0.480816	59	2928.47	3.4442	901.062	34.31%	35.15%
40	0.49656			0.49656	58	2921.4	3.37679	903.287	34.29%	35.06%
41	0.479417	0.492927		0.486172	79	2898.55	3.34725	914.098	34.21%	35.06%
42	0.479603	0.555948		0.517776	67	2889.52	3.33457	920.748	34.14%	35.05%
43	0.563767	0.630455		0.597111	90	2876.63	3.33328	927.119	34.12%	34.90%
44	0.486684	0.712322		0.599503	42	2791.04	3.29283	935.25	34.08%	34.83%
45	0.485077	0.723989		0.604533	94	2764.48	3.25928	940.754	33.90%	34.76%
46	0.52163			0.52163	89	2763.24	3.21115	953.976	33.85%	34.70%
47	0.527706			0.527706	97	2744.07	2.89979	962.613	33.80%	34.62%
48	0.528133			0.528133	88	2723.91	2.86472	967.921	33.73%	34.58%
49	0.499617			0.499617	22	2682.55	2.83563	970.527	33.70%	34.54%
50	0.452385			0.452385	41	2661.62	2.8203	975.068	33.68%	34.50%
51	0.508635			0.508635	21	2635.29	2.77632	975.944	33.68%	34.43%
52	0.461075			0.461075	20	2632.08	2.75296	999.984	33.66%	34.43%
53	0.477976			0.477976	39	2624.67	2.71852	1001.38	33.66%	34.43%
54	0.451007	0.492966	0.492816	0.47893	40	2618.11	2.63074	1002.78	33.62%	34.20%
55	0.455925	0.506855	0.470461	0.477747	0	2570.17	2.54228	1011.47	33.62%	33.92%
56	0.490521	0.511007	0.496818	0.499449	31	2564.42	2.52942	1065.83	33.45%	33.43%
57	0.537332	0.512792	0.488553	0.512892	23	2553.56	2.52421	1084.83	33.45%	32.76%
58	0.595403	0.520768	0.567139	0.561103	76	2523.88	2.47784	1100.25	33.40%	32.10%
59	0.608371	0.548908	0.533922	0.563734	35	2487.30	2.47666	1104.74	33.35%	31.68%
60	0.523643	0.54948	0.541975	0.538366	2	2453.29	2.47293	1109.29	33.33%	31.66%
61	0.471597	0.505568	0.538747	0.505304	82	2445.18	2.471	1117.6	33.33%	31.52%
62	0.401916	0.500462	0.541889	0.481422	87	2402.25	2.46544	1120.93	33.28%	31.52%
63	0.452399	0.495195	0.521851	0.489815	33	2402.17	2.46358	1156.46	33.28%	31.50%
64	0.461148	0.497263	0.610631	0.523014	30	2396.34	2.45355	1175.26	33.28%	31.49%
65	0.501778	0.522968	0.604404	0.54305	80	2385.07	2.44212	1190.6	33.28%	31.46%
66	0.520464	0.554682	0.62645	0.567199	24	2329.84	2.44034	1222.32	33.26%	31.42%
67	0.46698	0.581789	0.624346	0.557705	81	2230.26	2.42627	1224.4	33.26%	31.36%
68	0.463628	0.54937	0.612007	0.541668	25	2224.57	2.41875	1228.47	33.25%	31.36%
69	0.543703	0.584372	0.568354	0.565476	86	2213.24	2.40454	1236.16	33.23%	31.34%
70	0.560416	0.569105	0.578219	0.569247	32	2201.86	2.40061	1237.7	33.23%	31.27%
71	0.546652	0.553251	0.555609	0.551837	29	2177.53	2.39076	1255.8	33.23%	31.13%
72	0.53196	0.536533	0.551252	0.539915	37	2116.21	2.37471	1259.09	33.23%	31.07%
73	0.541538	0.519824	0.517604	0.526322	26	2077.75	2.35	1291.98	33.22%	30.79%
74	0.516499	0.413769	0.473457	0.467908	19	2068.03	2.34022	1355.71	33.22%	30.77%
75	0.501781	0.470194	0.606632	0.526202	28	2060.47	2.33317	1385.51	33.17%	30.54%
76	0.514391	0.581109	0.629972	0.575157	27	2046.98	2.33078	1388.76	33.16%	30.52%
77	0.500437	0.531865	0.605966	0.546089	83	1986.21	2.30461	1400.06	33.11%	30.47%
78	0.49721	0.506455	0.584814	0.529493	10	1975.01	2.30197	1415.37	33.11%	30.42%
79	0.482969	0.552156	0.646183	0.560436	3	1964.5	2.23818	1417.37	33.06%	30.15%
80	0.448372	0.556693	0.546583	0.517216	36	1952.8	2.23325	1661.14	33.06%	30.02%
81	0.465214	0.535229	0.527898	0.509447	4	1926.58	2.20431	1667.05	33.05%	29.77%
82	0.443452	0.478838	0.596752	0.506347	17	1918.94	2.19714	1987.51	32.97%	29.61%
83	0.396979	0.512527	0.551886	0.487131	77	1897.02	2.16965	2169.64	32.95%	29.54%
84	0.508781	0.473066	0.511562	0.497803	12	1876.11	2.16951	2537.47	32.80%	29.32%
85	0.376245	0.384967	0.524499	0.42857	13	1864.91	2.15762	2612.28	32.66%	29.20%
86	0.437263	0.461837	0.497811	0.465637	11	1853.16	2.15587	2828.6	32.65%	29.14%
87	0.416104	0.446282	0.47618	0.446189	14	1852.12	1.94428	2973.86	32.59%	29.07%
88	0.476056	0.464945	0.467209	0.469403	15	1845.6	1.94398	3390.74	32.48%	28.76%

Figure 7.4.5.

The evaluation values for the first 88 images of the sequence. The numbers were sorted and the valuable images were selected by the algorithm.

7.4.2. Selected Images

The images selected according to grey level deviation algorithms presented heterogeneous results. In extreme conditions the program was more successful in determining the proximity whereas in a wide spectrum of image types it was harder to differentiate the tonal characteristics in the images selected by the program.

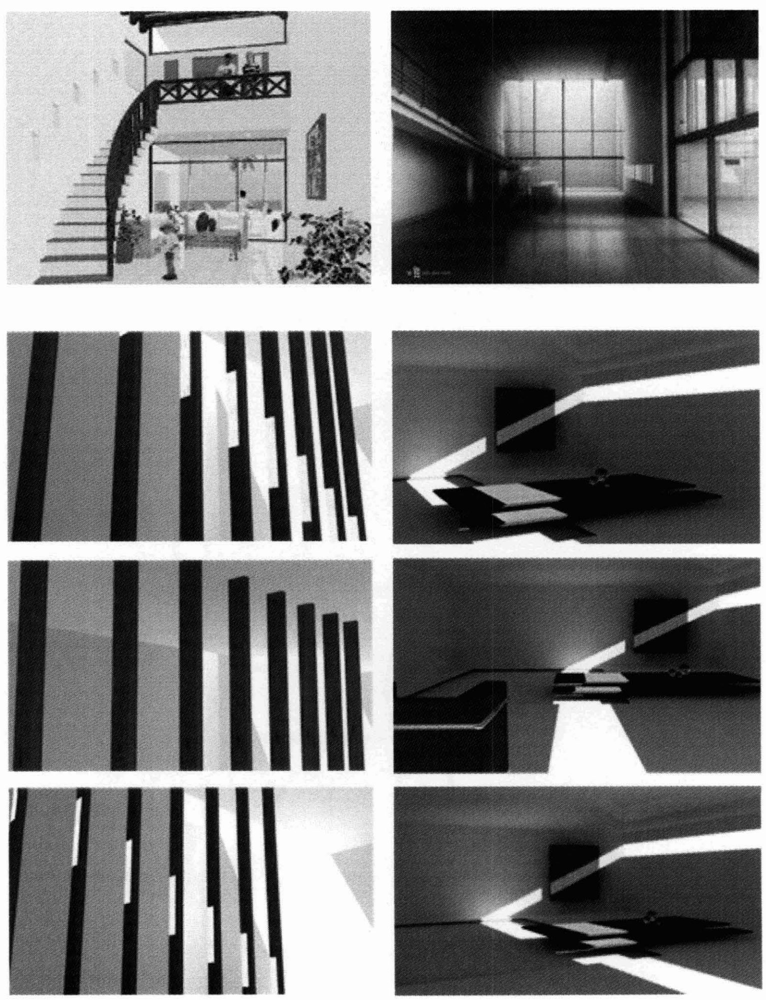


Figure 7.4.2.1.

Two reference images of extreme tonal difference and four images selected by the program. Note the proximity in the grey deviations in the surfaces.

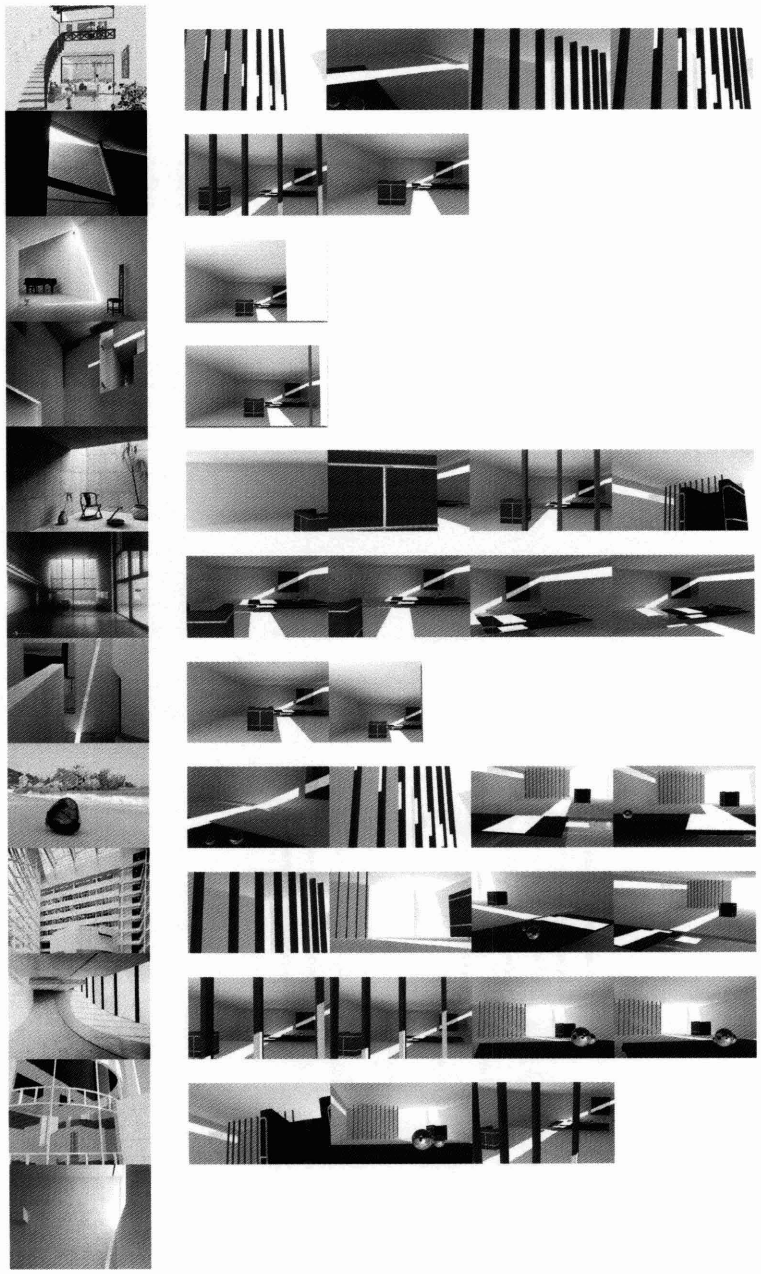


Figure 7.4.2.2.

Reference images and the images selected by the plug-in according to those. The tonal gradation represents similarities; however a definitive visual differentiation cannot be made.

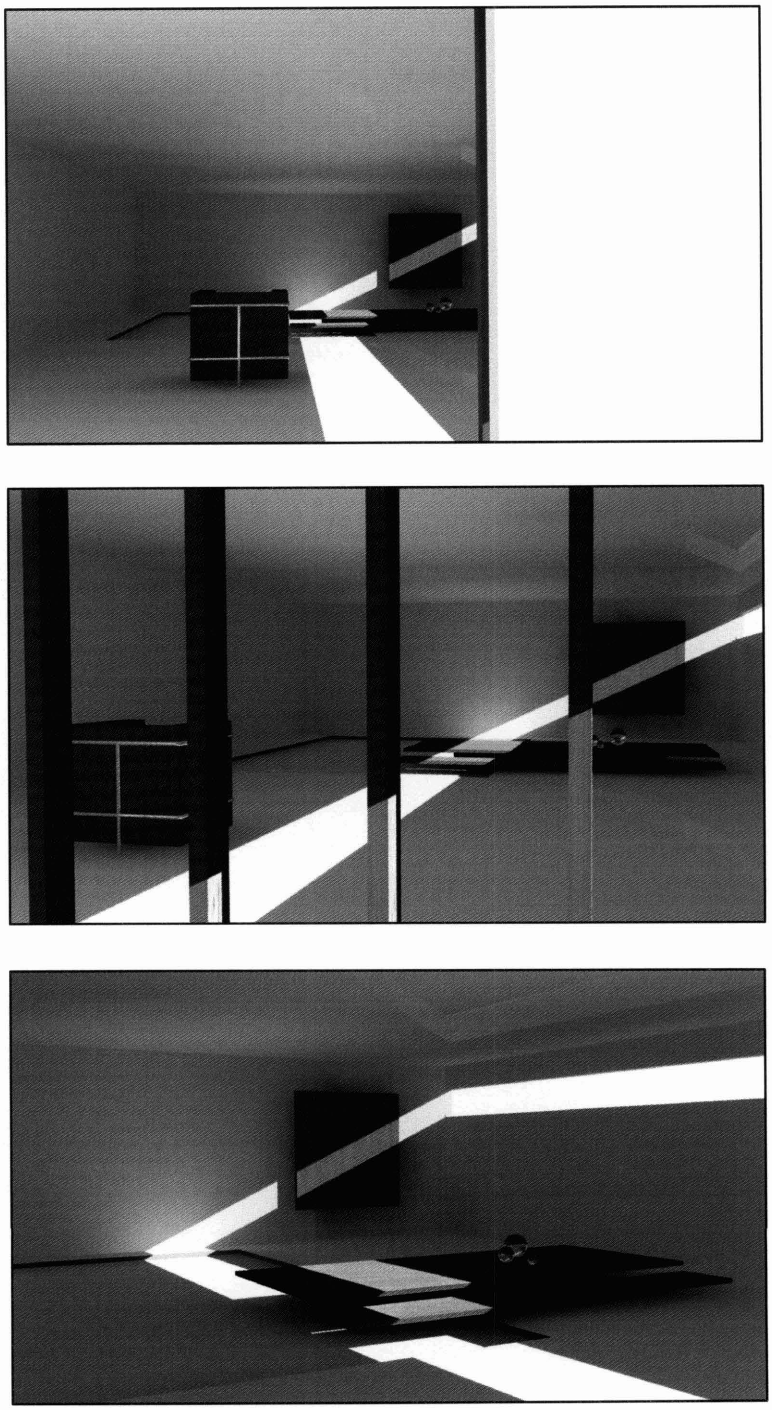


Figure 7.4.2.3.

Some images selected by the rule of thirds algorithm

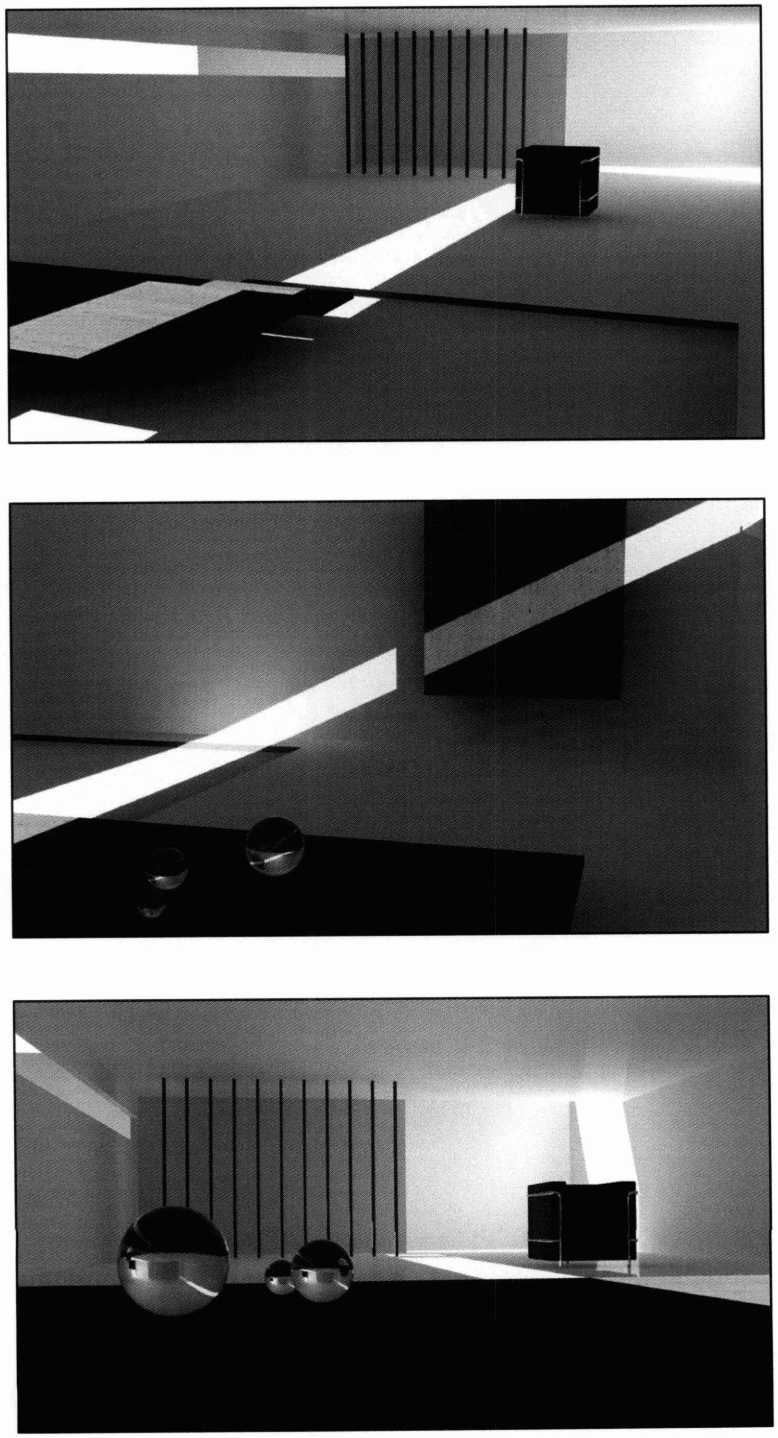
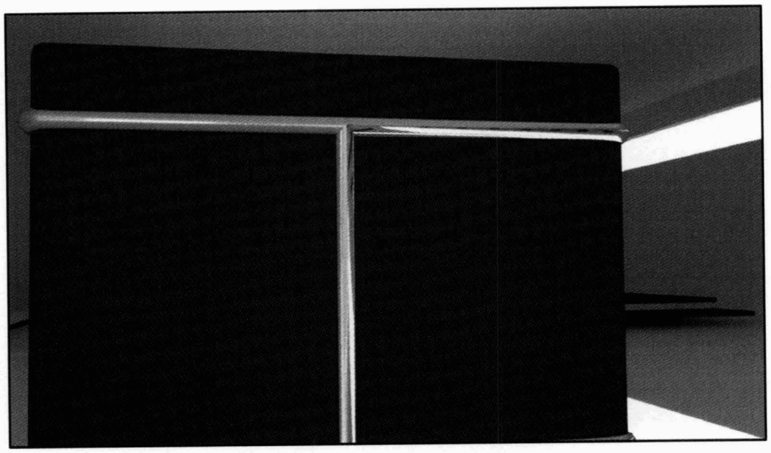
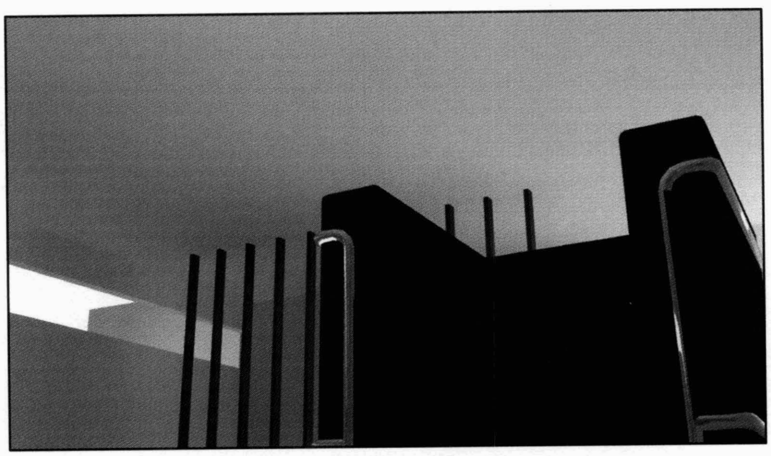


Figure 7.4.2.4.

Some images selected by the rule of thirds algorithm





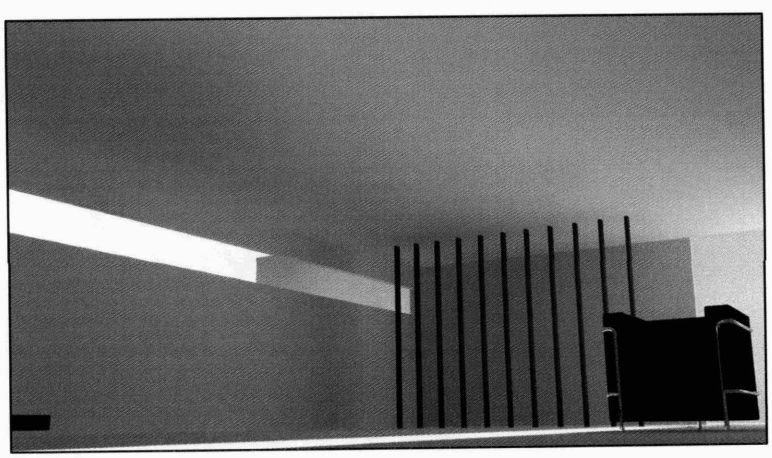


Figure 7.4.2.5.

Some images eliminated by the rule of thirds algorithm

The images elected by the rule of thirds algorithm represented more balanced compositions in the means distributions of dark and bright pixel areas. On the other hand, the very low ranked images were the ones with extreme unbalance conditions (Figure 7.4.2.5.) In these images, either a large portion of the canvas was covered with the objects in the scene or the compositional elements were too close to the edges of the image canvas to create a high quality composition.

Including some unintended biases, the algorithms for calculating the grey deviations and the value of the composition according to the rule of thirds mostly gave expected results.

8. Epilogue

8.1 Outcomes and Contributions

The proposed model of Narration of Light, intends to demonstrate possible methods and supporting computational tools for an image driven process in a rendering environment with certain level of quality recognition. With its consideration on image evaluation, this study also intends to make a touch to the problem of definition of visual qualities within the computational environment. Drawing its own territory with individual definitions of architecture, light and space, this research presents itself as an experimental study rather than a concluded theory.

After dealing with multi-faceted problems and theories in a wide range from spatial imagination to design computation, this thesis produces a programming project and also intends to test it for validation. Being open to further development, the implemented tools succeed in running an automated process of evaluating the rendered images. However the evaluation methods and techniques stay open to manipulation, implementation and further discussion.

In case of being used for visual exploration of digital models in early stages of design processes, the developed tool carries the potential of offering an extremely accelerated image production and election. The users of the tool ideally would be endowed with the computationally selected images. These images may guide the architects to different directions in the design process depending on the visual qualities they are looking for in the spaces they are creating. The architects may change and update their designs and digital models depending on the outcomes and re-run the process of image creation with use of the developed plug-in until they reach to more concrete designs.

The tool can also be used in concluded designs, to select the images that correspond to the qualities the authors seeking for.

8.2 Further Implementations

The very first implementation for the plug-in would be full-automation of the process. All algorithms, with little manipulations are ready to run altogether to offer an on-the-fly evaluation of the rendered images. Another quick implementation can be the insertion of different cameras automatically depending on the user preferences.

Some more complex implementations can be done in the algorithms for evaluation and for addition of an iterative process. For the latter, rather than running on a certain path while rendering, the cameras can iterate their own position depending on the compositional quality of the image they produce at a specific position. The feedback taken from the rendered image can help defining the next direction the camera would move to capture a better framing. The feedback for compositional setting can also be directly taken from the digital model which was not the consideration of this study since it was aiming a fully image dependant and image driven process.

8.3 Last Words

Personally, I see Narration of Light as an experimental study, in which the effort was put to create an intellectual bridge between imagination and computation. After dealing with many technical applications and vast amount of programming, I still accept the design inquiry and the insight we have about what we see as the source of motivation in this research.

Narration of Light

Image Sources:

All images are by the author unless otherwise noted.

Figure 3.2.1, and Figure 3.2.3.
Myers, Tracy, Lebbeus Woods and Karsten Harries. 2004. Lebbeus Woods - Experimental Architecture. Pittsburgh: Carnegie Museum of Art.

Figure 3.2.4.
Arkitera, Türkiye'nin Mimalik Yayini Webpage.
http://www.arkitera.com/news.php?action=displayNewsItem&ID=6744

Figure 3.3.1.
Peter Gric fine art Webpage
http://www.gric.at/gallery/bild077.htm

Figure 5.1.
(Photoshopped from) Das Geheimnis des Schattens : Licht und Schatten in der Architektur. 2002. New York, NY: Available through D.A.P.

Figure 5.3.1. and Figure 5.3.1.
Special permission: Assoc. Prof, Takehiko Nagakura, Massachusetts Institute of Technology

Figure 5.4.1
Mark Harden's Artchive Webpage
http://www.artchive.com/artchive/m/mondrian/mondrian_composition_a.jpg

Figure 5.4.2.1 and Figure 7.3.2.2.
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Figure 6.2.1
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The End