Master Thesis

Design & Engineering

ADAPTIVE LIGHTING

A Research On Interactive Lighting Design and Technologies

The New Lighting Design Project "LUVI"

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Abstract

The development in technology offers to designers, the possibility to create new and interesting user experiences. In this thesis, the research is based on the two fields, design and engineering, in order to understand the methods and opportunities to create a new lighting design with an innovative way of interaction.

The research includes the lighting technologies and interaction methods, the constraints of the design for a good lighting, the recent lighting trends, technical definitions and methodologies for lighting, interaction and user experience design.

The usage and importance of interactive products in the daily life increases everyday and the digital interaction attracts the attention of most people. These digital interfaces became as a normal and natural behavior. Depart from this situation, the new lighting design 'Luvi' is designed with the aim to create a real 'natural interaction' for the user. With this aim, the natural daily activities of the target user have been observed and analyzed. So, this new lamp doesn't need to be activated or an additional effort for interaction, but it automatically reacts to the defined actions of the user. This innovation aims to facilitate the daily life by using a good lighting and interaction.

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CHAPTER 1:
INTRODUCTION

Explanations about the aim of the research and the project

A guide for the incoming chapters

1.1. Thesis Contribution

The aim of this dissertation is to perform a research within the lighting and interaction design fields, including the technical information to create a good lighting design, the technological possibilities, the constraints of lighting design, information and examples for interaction design and technologies, user experience design and many other areas that will be helpful to design an interactive lighting fixture.

The thesis can be considered as four parts; the first part is the research step in which the studies on lighting design, interaction design, lighting technologies and user experience design are made. The second part includes the design strategies. At this stage the needs and the aims of the new design are defined, the methods to be used to realize them are determined. The third part is the design development stage in which the new product starts to be shaped by the definition of the concept, the listing of the functions, the determination of the technological methods and the sketches. The last part consists of the documentation and presentation of the final design.

The research part includes all the data that is necessary to build a good lighting design. The criteria for the selection of light source, layout, lamp etc. are learned and defined. The technological tools that are useful to realize an interactive lighting have been analyzed. The possible needs and expectations of the user have been searched and the information about User Experience Design are documented.

After all these researches, the path for the new light design has been defined. The aspects that are the main aims are defined and placed in the center of the project. Then, the needs and functions for the new design has been documented and the map of the design process has been created.

The new lighting design 'LUVI' is a multi-funcational that can be used both for functional and entertainmental needs. The design has two versions with different levels of implemented technology, while both of these are based on the same simple design.

The first and basic version of the LUVI lamp is designed with the aim of providing a night light that is useful in cases of the need of light in the night or when arriving hıme in the evening. The aim of the optical construction and the created effect is to offer a light source that doesn't disturb the eyes of the user as well as the other people in the house sleeping at the night time. The purpose of the use in the evening is to avoid the annoying situation of staying in the dark when entering in the house.

The second and upgraded version of the lamp includes a higher level of technology. Additionally, this version of the lamp is planned to be sold with an interactive control panel. The aim of this combination is to offer the possibility to create an atmosphere in the room. The idea is inspired fro Philips Hue, while the interactive processes and the related technologies are developed differently.

During the design process, the technical criteria mentioned in the research part -such as the selection of the light source, lamp, sensors, etc.- are considered and respected. The final design can be considered as a result of the whole research.

1.2. Dissertation Roadmap

This title includes a general summary of the incoming chapters. This aims to give a broad idea to the readers about the methodology of the thesis and the structure of the research going through the creation of the new interactive lighting design.

1.2-1. Design for Interaction (Chapter 2)

As the new lighting design is planned to contain interactive features, it was necessary to learn about the essentials of interaction design. So, this part is based on the analysis of interaction design and its elements.

The first step to do is to define the area. So, the first title includes the definition and uses of interaction design without going too deep, with the aim to understand and internalize the main idea and aims of interaction design field. Additionally, the ways to approach to the field are explained in order to understand the relationships of interaction design with other design and engineering fields. The next step was to learn about the constraints of the methodology. For this, the principles of interaction design are investigated and studied.

The next topic of this chapter was about the connection of interaction design to the use of technology. As studied before in the same chapter, this area is somehow linked to the technology and this is the reason why the technological side of interaction design has to be studied. This part explains that interaction design is an aspect implemented in a product through technology.

The next level is to learn about the technological tools and components that are used to implement the interaction in the product. It is directly related with the previous topic but at this stage more details are given and all the tools that are used to control a device or product are identified. The explanations include the buttons and switches, touch screens, gesture and voice control technologies, wearable devices, smart surfaces and mobile apps are defined, explained and exemplified. However these methods are not directly related to the control of a lighting fixture, but these are the general techniques to be used in any interactive design.

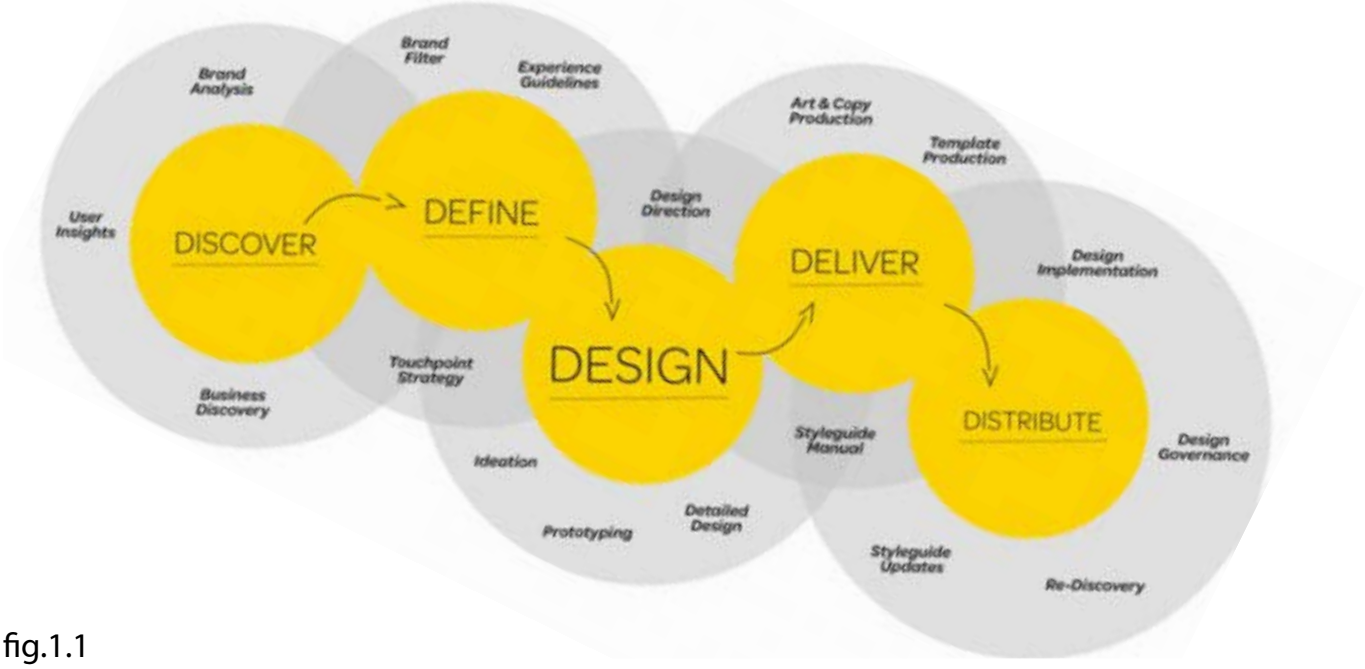


fig.1.1

In the next title, the ways to implement an interaction into a product design are identified. The tools that can be useful for the application are searched and explained. In this level the book of Gillian Crampton Smith in which the dimensions of interaction are identified, has been very helpful. The next step of this topic was the relation with lighting design, and the implementation methods of interaction have been explained in a narrower way.

Briefly, this part explains that interaction design is a mix of a variety of fields. It uses the technology as a tool to perform functional and impressing designs for the consumers.

1.2-2. Lighting Technologies (Chapter 3)

This chapter begins with the identifications and definitions of the electrical light sources. The incandescent lamps, the discharge lamps and tungsten-halogen lighting are explained in details, while an introduction to LED lighting is performed. As there is a more detailed part for LED lighting in this chapter, this part was about the general uses, advantages and disadvantages of this technology, explained in a broad sense.

The next part is based on the comparison of the light types with each other. For this comparison, the most popular and currently used lighting technologies are selected. The incandescent lamps, the CFL (Compact Fluorescent Lamps) and the LED lighting are compared with their characteristics of life span average, electrical consumption, cost, Eco-friendliness, light output and other characteristics that may influence the choice of light type.

After comparing the lighting technologies, the next step was to determine the contemporarily popular light sources. The features and the constraints of architectural structures influencing the lighting choices have been defined and explained. It has been declared that the choice of lighting method depends on some criteria and this criteria has been identified within the design point of view. Depending on this analysis the LED lighting has been found as the most flexible lighting source that can be used in a variety of shapes and applications. So, in the next part, it was necessary to examine the features of LED lighting which became very popular in the last years.

The next part was about the methods and tools that are related to the control of the light. There are many different ways to control a single lamp, while it is possible to efficiently control the lighting of wide spaces. All the methods and technologies for controlling the different features of light have been determined and explained with reasonings.

The last part is based on the presentation of LED lighting technology. First of all, it has been explained what is an LED exactly. Then, the working principle of an LED has been defined 'basically' avoiding very technical and detailed engineering data. The aim of the next topic was to show the usage areas of LED lighting in daily life. Last, the advantages and disadvantages of replacing a regular light bulb with an LED light bulb have been considered.

1.2-3. Lighting Design and Trends (Chapter 4)

This chapter has been chosen in order to understand and explain the readers the constraints affecting the choices of the lighting designer. These constraints are mostly coming from technical restrictions and needs, while some of them are directly related to design, changing the physical and psychological effects of the light on the user. The technical restrictions are related to the
selection of the light bulb, (partly) the selection of the fixture, the control system, limitations of installation, the costs and ease of maintenance. As some of these aspects may only 'touch' to design, the selection of the fixture and the lighting layout are primarily related to the design choices.

The second part is made of the design trends of lighting sector in 2016. The mentioned trends are the result and synthesis of the research, containing the data obtained mostly from publishes in known and confidential design magazines. For obtaining this result, a variety of publishes about lighting and even interior design trends have been analyzed and verified by comparisons. Finally, those 14 trends have been chosen to be placed as the 'trends of 2016'.

The last part of this chapter is the benchmark analysis. A variety of lighting designs realized in 2016 have been investigated and studied. The 'Salone del Mobile' has been visited and he names of the most stunning lighting designs have been noted with their designers. This was the first part of the benchmark analysis made up of eight examples from Salone del Mobile 2016. The second part includes the research on the Swedish designs exhibited in Stockholm this year. Six lighting fixtures have been included in this part as examples from Swiss.

Next, the ICFF (International Contemporary Furniture Fair) has been studied. The lighting designs that are exhibited in ICFF have been found and seven eye-catching examples that have clear explanations have been chosen as examples – as the fair is ended short while ago, most designs were not exactly identified with their features and the names of their designers – .

The next stop was France, Maison&Objets. In this fair a variety of designs have been found; while one of them was Cyborg from Karim Rashid. Three striking examples have been chosen from Maison&Objets 2016.

1.2-4. Designing the Experience (Chapter 5)

The most important factor of interaction design is obviously the experience of the user during the use of a product. This part aims to determine the features of user experience design.

First, it was necessary to determine the needs and habits of the user when controlling a lighting system. For this analysis, the answers of thirty-five persons for the questioning have been collected, synthesized and adapted as results for a general profile. The needs and expectations of these people are generalized as guidelines for this analysis.

In the second part, two terms that are UX (User Experience) and UI (User Interface) have been defined and diversified. The methods to create an efficient UX have been studied and UI has been determined as a tool for UX design. The usage areas and benefits of UX have been explained and the elements of UX have been listed. The next level was explaining the strategies to create a good and efficient experience for the users.

The three main steps of user experience design are listed as "user definition", "problem definition" and "possible solutions". For this, the most important 'first' step was to understand the lifestyle and culture of the target user. So, the psychological side of UX has been studied and its importance has been clarified.

The second step was the definition of the specific problem. For this, again the central position of the user for the design development has been explained. The important fact was that the design has to carry a specific problem of the user that has to be solved. At this stage the importance to keep the user and his problem in the center has been explained.

Finally, this part is basically about the methodologies that are needed to be used to develop an understandable and useful experience for the user.

1.2-5. Design Development (Chapter 6)

With this chapter the design process starts and the characteristics of the product start to be defined. First, the concept is determined and explained. Then, the key needs of the design have been clarified and the characteristics of the expected final product have been pre-determined.

After these, in the rest of the chapter, the design development stage is shown by sketches and rendered visualizations. In this part, the readers are able to follow how the final design has been reached.

1.2-6. The Presentation of the New Lighting Design (Chapter 7)

This final part includes the whole presentation of the final light design LUVI. The two concept of use and the storyboards are visualized as well as the technical issues and solutions.

This part can be considered as divided in two; in the first part the functional light concept has been shown as a single design. The second part includes the data of the entertainmental design of the product and interaction.

CHAPTER 2:
DESIGN FOR INTERACTION

Definitions, Methods, Applications and Technological Relations of Interaction Design

This dissertation proposes a new way for interacting with the objects. This new interaction is based on an easier and more natural way for the user to use and interact with the object. To realize such a new kind of interaction, it is necessary to study and understand the interaction,

2.1- Definition: 'Interaction' and 'Interaction Design'

'Interaction' is a very wide-sense term that can be related to many fields of professions, but in reality, it is a perpetual and constant part of the life. It's an important factor of human relations and it's getting more popular in the daily life by the integration to the 'product design' field. Each day, each moment contains an interaction with an object, a device or a person in the modern life.

Dan Saffer provided a simple definition for interaction in his book '*Designing for Interaction – Creating Innovative Applications and Devices*':

"An interaction, grossly speaking, is a transaction between two entities, typically an exchange of information, but it can also be an exchange of goods or services."

According to the common definitions, interaction has two meanings: intermediate action and 'action on each other; reciprocal action or effect'. This latter meaning suggests social interaction and also what is thought of as biological interaction. There is, however, no universally accepted definition of interaction in either biology or statistics. In the broadest sense, the term only implies that objects or factors in a study do not act independently. Many 'working' definitions are directly based on the statistical characteristics or measures of interaction, often causing misunderstandings. To reduce ambiguity, it is generally preferable to couple the term 'interaction' with other descriptive words or phrases, although many of these still have no clear-cut and generally accepted definitions.

In this dissertation, the term 'interaction' is used together with the 'design' field, in order to understand the relation of interactive elements implemented into the industrial design products.

A narrow definition of 'interaction design' according to Bill Moggridge is: "The design of the subjective and qualitative aspects of everything that is both digital and interactive, creating designs that are useful, desirable, and accessible." A broad definition of 'interaction design' is: "The design of everything that is both digital and interactive." (Designing Interactions, Chapter 10: People and Prototypes, 2007)

Interaction was a part of the life from the beginning of humanity; the five senses are the signs showing that interaction is a natural behavior of Man. Speaking, listening, touching, smelling and tasting are the natural ways for interacting with the other people and the environment.

Interaction design is a field that is inspired of these natural ways of interaction and that applies the five senses into the tools of the modern life.

Three Ways of Looking at Interaction Design

There are three major schools of thought when it comes to defining interaction design:

1. A technology-centered view
2. A behaviorist view
3. The Social Interaction Design view.

Technology is an important part of interaction design that makes a lot of aspects possible and real. Most of the interactive products are based on the use of technology and the technological development. These Technologies are used to construct a new behavior for the user and this is called the 'design of interaction'. As mentioned before, the basis of interaction is the contact with the other people and the environment, that makes the social aspects pretty important fort he daily life of the user.

Interaction Design Principles

The principles of interaction design are the tools to better create the behavior, the form and the content fort he new interaction. These principles, in reality, are based on the experiences and values of the designers.

"Principles operate at different levels of detail."
(Alan Cooper, About Face – The Essentials of Interaction Design, 2007)

Design values describe imperatives for the effective and ethical practice of design.

Conceptual principles help to define what a product is, and how it fits into the broad context of use required by its users.

Behavioral principles describe how a product should behave, in general and in specific situations.

Interface-level principles describe effective strategies for the visual communication of behavior and information.

Basically, interaction design is to design for people. It aims to answer the physical and the emotional need of the user. Interaction design can contain physical and digital input, as well as it may provide the integration of the digital interface into a physically interactive product. The primary aim of these integrations is to provide 'action', 'feeling' and 'information'. The basic interactive process is based on performing an action to feel something and to get information. The easiest interaction requires the knowledge for a single step of interaction; while nowadays the complexity of behavior became a challenge for the designers.

2.2- The Relation of 'Interaction Design' with Technology

Design of the interactive objects generally requires the application of a digital technology. Touch screen phones and products are the best and most common examples of the use of technology for product design. In this field, interaction design, technology and product design are intertwined.

The development in technological devices brings a need of change in product design. The new technologies bring new opportunities for interaction design. On the other hand, the modern interactions are mainly based on technology and the use of multimedia too. The use of screens, sensors, cameras, projections and many other elements is the main fundamental of interaction design.

The interaction of the modern devices is simply the digital imitation of the natural human behaviors during the social and physical interactions. To imitate or simulate the human behavior and integrate into the daily products, the designer needs the use of technology.

There is a definition of interaction that represents the relation of interaction with the technology:

"The design of everything that is both digital and interactive."

In this sentence, it's obviously expressed that interaction has a digital side which is significant in design process.

2.3- The Tools and Control Methods for Interaction Design

There are many methods to create an interactive device. The digital technologies are the most common ways for interaction design and are based on two main parts: 'hardware' and 'software' construction.

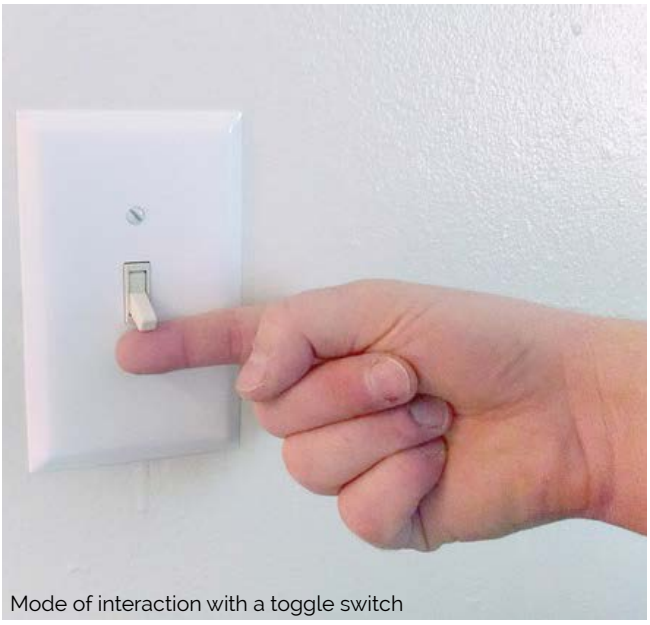
The software involves the codes and scripts to create and control the behavior of the hardware devices. The hardware components can provide interactions concerning to the fives senses. The screens and monitors are concerning to vision, the speakers, earphones etc. to hearing and there are many ways that concern to tangible interaction. Contemporarily, the tangible interaction is the most common and powerful way of interaction. The ways and methods for tangible interaction are listed below:

1. Buttons and Switches
2. Touch Screens
3. Gesture control
4. Voice Control
5. Wearable devices
6. Smart surfaces
7. Mobile Applications

2.3-1. Buttons and Switches

The buttons –also called as a 'push-button'- are the most traditional way to control the machines or devices. It's a simple mechanism typically made of hard material, usually plastic or metal. They contain a spring to return to their 'un-pushed' state.

The push button is used in calculators, phones, kitchen appliances, lamps and in many other products to perform the turn-on and turn-off actions.



Mode of interaction with a toggle switch

Mode of interaction with a push button

A switch is a component that can break an electrical circuit, interrupt of divert a current from one to the other conductor. It can either be controlled by a human operator, a moving object, as or a sensor. For example, a human operator can turn on or off the light by the switch, the door's rotation can be a factor for the operation or a sensor detecting temperature, pressure or flow can be used for activation or deactivation of a function. A switch can be defined as a 'change of state'.

There are several kinds of switches:

- Toggle Switch
- Push Button Switch
- Selector Switch
- Joystick Switch
- Lever Actuator Limit Switch
- Proximity Switch
- Speed Switch
- Pressure Switch
- Temperature Switch
- Liquid Level Switch
- Liquid Flow Switch
- Nuclear Level Switch

The simplest switches are based on the contact of two electrical conductors with each other by the movement of an actuating mechanism. The other types of switches tend to be more complex, they contain electronic circuits in order to turn a function on or off, depending on sensed information.

The switches can be categorized in three main topics:

a. Light switches

These switches are commonly used in the buildings in order to operate the electric lights, the connected equipments or an electrical outlet. The stable or portable lamps contain a light switch connected on the socket, basis or on the cord. As manual switches are more common, a light dimmer or a remote controller can be replaced with the manual switch. The light switches are also used in the flashlights and in the automotive sector.

The light switches have variations within the design field;

- The push button switches are the traditional choices that are based on two buttons to alternatively turn on or off the contact.
- The toggle is based on a snapping action through the use of "over-center" geometry.
- An illuminated switch is a switch enlightened by an LED behind. It helps to find the switch in the dark easily.
- A rocker is the alternative of the toggle switch. They are more decorative than the toggle with the larger pushing top surface.
- A temper resistant switch is used in the places where the switch should not be turned on or off accidentally. (A vandal-resistant switch, for example)
- The voltage class aims to provide higher voltage than the regular switches.
- The mercury switch is known with its silent operation possibility. They were popular before 1970s.
- The pull chain or cord switches are used for the switches that are on the basement or utility areas of the houses. The chain or the cord is used to reach to the distance of the switch.
- Dimmer switches aim to adjust the level and intensity of the light. However they cannot be used together with LED which is the contemporarily popular lighting method.

b. Electronic switches

The main idea of electronic switches is to control the current by the signal to a solid-state device to complete the circuit instead of controlling the current directly by the mechanical contacts. This theme has many variations that are created and marketed. An example of this method is the 'touch plate' which can be operated by the touch or motion of the hand of the user. They don't contain moving parts and they electronically switch the light circuit.

c. Other switches

There are many other types of switches with different circuits depending on different applications:

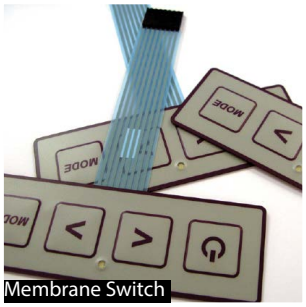
- Centrifugal switch
- Dead man's switch
- Fireman's switch
- Hall-effect switch
- Inertia switch
- Isolator switch
- Kill switch
- Light switch
- Latching switch
- Load control switch
- Membrane switch
- Piezo switch
- Pull switch
- Push switch
- RF Switch Matrix
- Sense switch
- Staircase time switch
- Slotted optical switch
- Stepping switch
- Switch access
- Electric switchboard
- Switchgear
- Thermal switch
- Time switch
- Touch switch
- Transfer switch
- Zero speed switch


Kill Switch


Centrifugal Switch

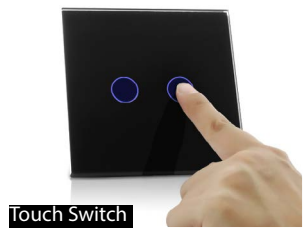

Pull Switch


Dead Man's Switch


Membrane Switch


Push Switch


Piezo Switch


Touch Switch


Latching Switch

2.3-2. Touch Screens

a. Technological Principle

There are a variety of touch screens, while the most common and known applications are based on 'resistive' and 'capacitive touch screens.

Resistive Touch Screen

A resistive touch screen panel is made of several layers. The most important two layers are thin, transparent, electrically resistant and they are placed to be faced to each other with a thin space between. The upper screen which is touched has a resistive coating on it. One layer contains conductive connections on its side walls and another one on the top and bottom surfaces. A voltage is applied to one layer and sensed by the other one.

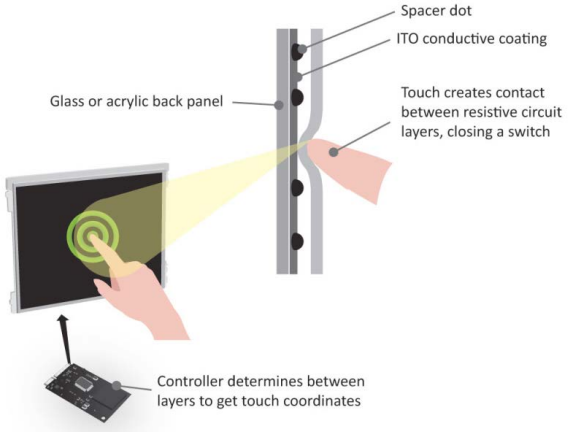


fig. 2.1: Mode of interaction with a resistive touch

Its high resistance makes advantageous to use it in hospitals, restaurants and factories thanks to its high resistance to liquids and contaminants. It also has the benefit of 'low-cost'. Additionally, the resistive touch screens need a higher pressure to be sensed, which makes possible to use it with gloves and other wearable equipment. However this feature creates a disadvantage for the use with naked hands. They have always to be used by the gloves or a digital stylus for a more comfortable experience.

Capacitive Touch Screen

A capacitive touch screen panel is based on an insulator as glass, coated with a conductor which is transparent. The human skin which is naturally an electrical conductor causes a distortion of the electrostatic field of the screen when touching. This distortion is measurable as a change in capacitance. Then, the location information of the touch is sent to the controller for processing.


fig. 2.2: Mode of interaction with a capacitive touch

Differently from the resistive touch screen, the capacitive screens cannot be used with gloves. This creates a disadvantage, especially in consumer electronics, by obstructing the usability of the devices in cold weather. For this situation, the user needs to have a special kind of gloves which has conductive zones or a digital stylus. On the other hand, these screens are much more sensitive in touching, which makes the use of the devices easier.

b. Interaction

The touch screen –as mentioned within their name- is the technology that offers a 'tangible interaction' opportunity. This kind of interaction, nowadays, is in each moment of our lives. The smart phones, tablets, remotes and many other devices use this technology, and it creates a new digital world with new functions and possibilities.

The touch screens' interaction can be defined as an upper level of the combination of the buttons and the mouse, while it offers a more 'natural' way of interaction. The one-touch selection function is the newer version of the push-button; while the slide motion could be performed only by a mouse 40 years ago. The touch screen has been invented in 1965 by E.A. Johnson.

In the contemporary technological world, the touch screens are used very often, because it became as a simple technology. It is currently used in the multimedia devices such as the phones, tablets, players etc., in public machines like the ticket selling machines or kiosks, in medicine, in design, in engineering and in many other fields.

In some cases, the patterns can be used for free form interactive gestures. These examples demonstrate a set of touch gestures, though these are not meant to be the only set of touch gestures. The touch gesture may vary and heavily dependent upon context of use, type of application, touch screen technology etc. These gesture designs aim to offer a more enhanced and natural way of interaction.

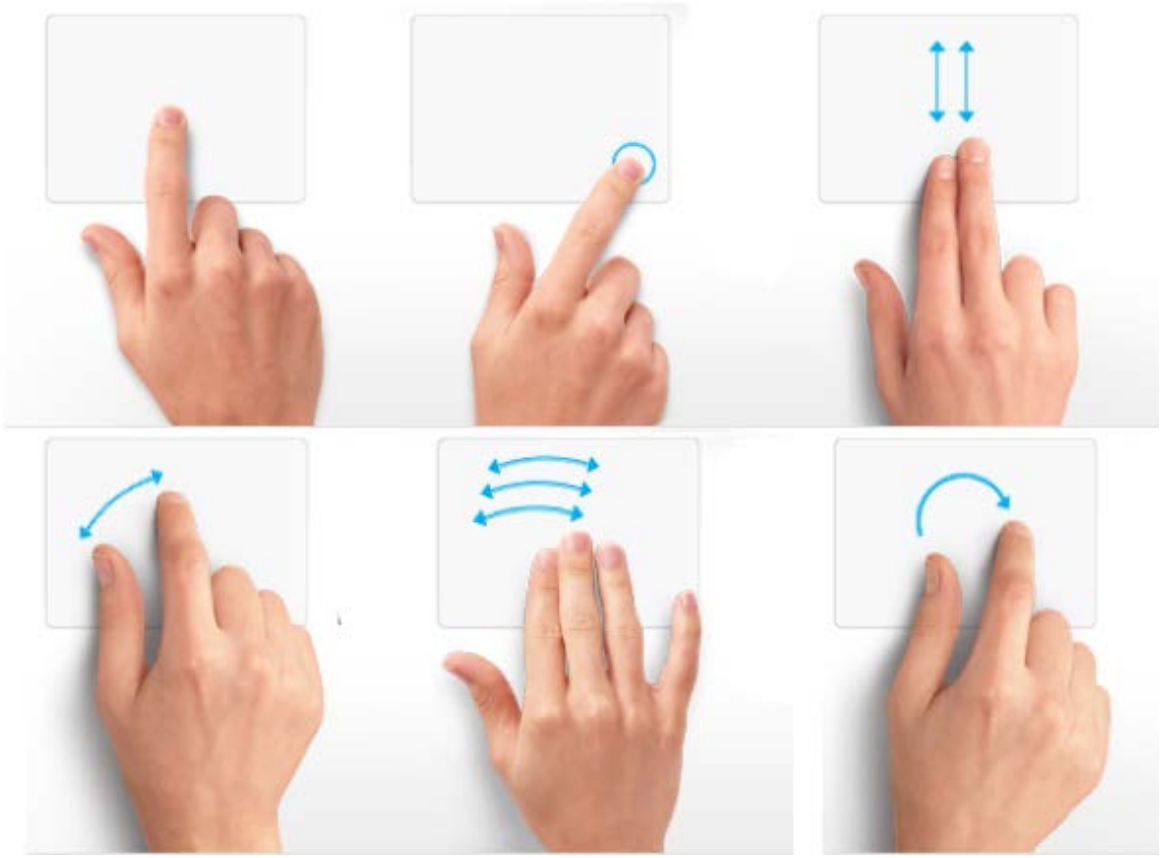


fig.2.3

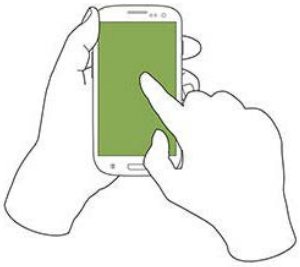
During the use of a touch screen the user should be able to accurately select the targets on the touch screen and avoid selecting the targets that are too near to each other for using the touch screen in an effective way. So, the design of the touch screen device should be realized by keeping the 'ergonomics', 'cognitive psychology' and the 'human psychology' in consideration.

The portable touch screen devices can be held in a variety of ways by the user, and the user would change the method of holding and the position of the device routinely, to find a more comfortable angle and position of grip. There are four types of handheld interaction:

1

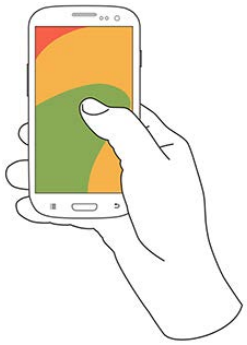
Holding the device with both hands and to tap by a single thumb.

2



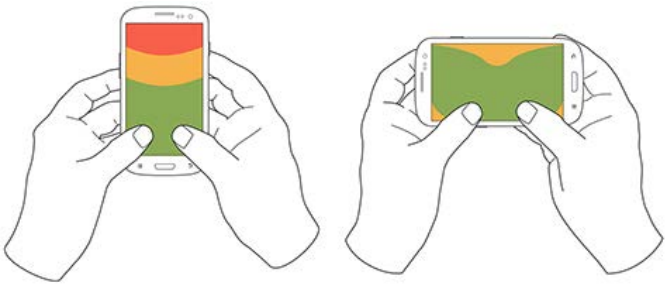
Holding the device in one hand and to tap with the finger of the other hand.

3



Holding the device in one hand and to tap with the thumb of the same hand.

4



Holding with both hands and to tap with both thumbs.

The rates of usage of these four categories vary depending on the application. The two-thumb tap is preferred rarely for many applications (1-3%), while it's used for 41% during the typing activities.

Additionally the devices are used by placing them on horizontal surfaces such as a desk, and the tablets are used in stands. In this case the user has the possibility to point, select and gesture more accurately with the finger or thumb; again, depending on the target of use.

One of the problems of touch screen in the use is the fingerprints on the display. To solve this problem, many ways are developed such as optical coatings to reduce the visibility of the fingerprints on the glass screen.

2.3-3. Gesture Control

fig. 2.4

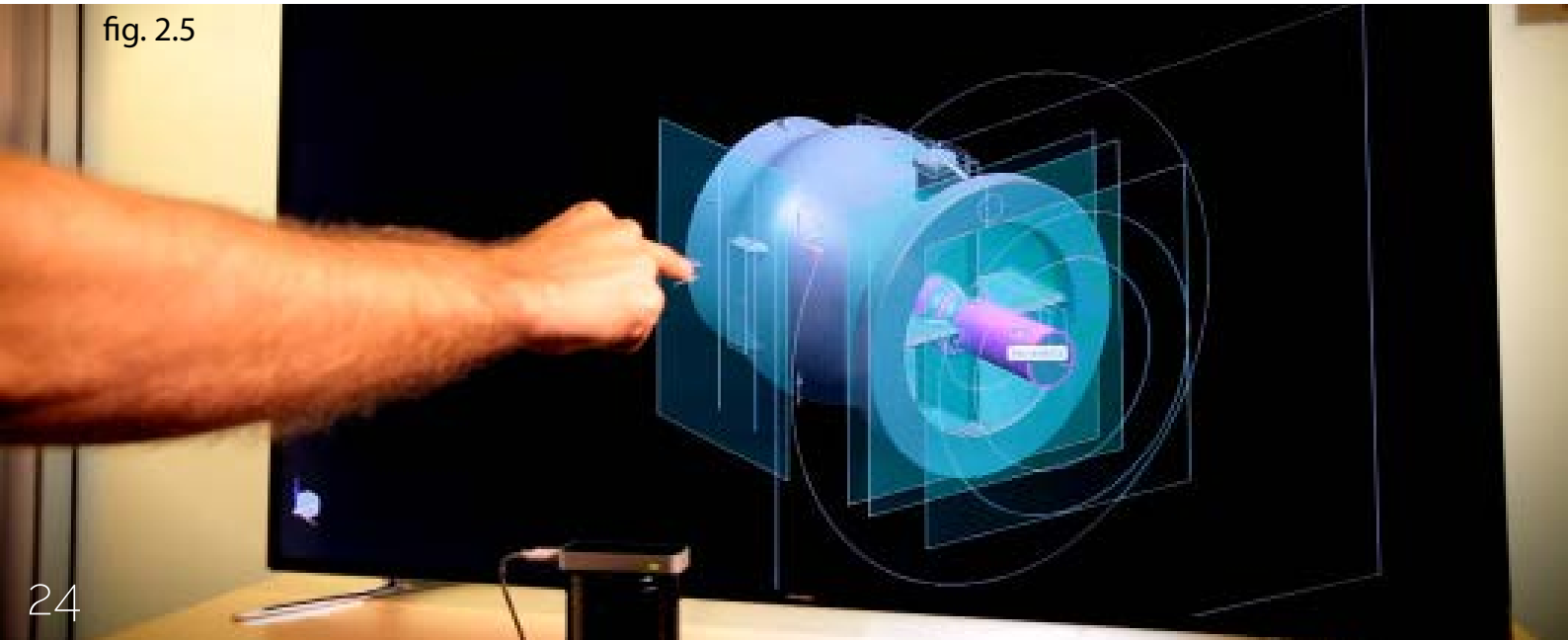
Gesture control simply is the opportunity to control or manage a device without touching, just by the motion of the hands, arms and the other features of the human body. This interaction is based on the "gesture recognition" technology. Gesture recognition allows the user to communicate with the digital objects and interact naturally without any mechanical devices. It can detect the motion of the gesture, as well as it can detect the emotions by recognition of the movements on the face.

Using this concept and technology, it is possible to use the point of the finger as a cursor on the computer screen, so that the cursor will move according to the motion of the finger. This will probably make the older input devices such as mouse, keyboard and touchscreens inessential.

This interaction and technology involves two types of gestures:

1. Offline Gestures: In this case the reaction is performed just after the gesture. (A gesture to activate a menu, for example.)
2. Online Gestures: Direct manipulation gestures. They are usually used to scale, rotate or move a tangible object.

fig. 2.5



Input Devices for the Gesture Control:

1. Wired Gloves: These provide information to the computer about the position and rotation of the hands using magnetic or inertial tracking devices.
2. Depth-aware Cameras: Using specialized cameras such as structured light or time-of-flight cameras, one can generate a depth map of what is being seen through the camera at a short range, and use this data to approximate a 3d representation of what is being seen.
3. Stereo Cameras: It is based on the usage of two cameras; one for detecting the position (3DOF) and the other one to detect the rotation(3DOF). In this way, 6D gestural motions can be detected.

4. Controller-based Gestures: These controllers are like an extension of the body, so that they capture a part of the gesture to send its data to the computer. The mouse is an old example of this principle, while 'Wii' and 'Leap Motion' can be shown as the newer applications of this technology.
5. Single Cameras: Nowadays it's being challenged in some companies to use a standard 2D camera to detect the motion of the human body. However it's considered that this
method is not as effective as a stereo or a controller.
6. Radar

Algorithms

There are different ways and approaches for the interpretation of the data for a gesture, according to the type of the input data. However most of the methods are related to the use of some key points which are represented in a 3D coordinate system. The relative motion of these key points is used for the detection of the gesture. The first proposal for the 'Human-Computer Interaction' is made by Quek.

There are three models for the gesture algorithms:

1. 3D Model-based algorithms
2. Skeleton-based algorithms
3. Appearance-based models

fig. 2.6

1. 3D Model-based algorithms

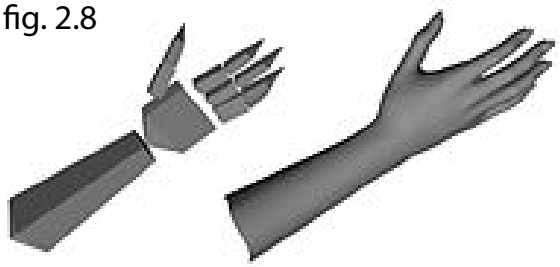
fig. 2.7

In this method, a 3D model in a volumetric or skeletal structure or even a combination of them is used. The volumetric type of models is usually preferred in the computer animation industry and for computer vision applications. The 3D models of these applications are usually the complex combinations 3D surfaces, such as NURBS or polygonal meshes.

An interesting and contemporary approach to this technique is to create simple and geometric illustrations of the components composing a human body and to analyze the gestural motions of these parts relatively to each other.

2. Skeleton-based algorithms

fig. 2.8



This method is based on the simplification of the complete and realistic 3D model to the one that is composed of the main components and joints. This simplification avoids many complications during the modeling as well as for the gesture. The main three advantages of these algorithms can be listed as:

- It is faster thanks to having only the key parameters to be analyzed.
- It allows matching a pattern against to a template database.
- As the model is made only of the key points of the object, the detection becomes easier by focusing on the significant parts.

3. Appearance-based models

fig. 2.9

In this method, the information of the parameters is received directly from the images or videos using a template database. This allows the use of deformable 2D templates of the human parts, usually the hands. The 2D templates are composed of points and are the outline views of objects or components. By the gesture detection, the outline of the part (hand, for example) moves to perform the digital reaction.

Another approach within the appearance based model is to use image sequences as the template of the gesture. In this case the parameters are also the outline points of the image itself. Usually, one or two views are used and these two methods are called 'monoscopic' and 'stereoscopic' methods.

The market is changing so fast because of the developing technology, and the gesture recognition technology becomes more and more popular. The manufacturers are gravitating towards this technology and the gesture recognition technology is estimated to be grown more than 15 billion dollars and 29.2% within the years 2013-2018. Currently, the 99% of the consumer electronics contribute on the gesture recognition technology.

fig. 2.10

2.3-4. Voice Control

The control of the devices by speech is a current and partly popular way to command the consumer electronic devices. The digital assistants that exist in most of the smart phones are the common examples of voice control interaction.

In reality, this method is based on 'Speech Recognition Technology' This technology is based on a set of words and expressions implemented on a computing device. When spoken towards the software, the device detects the words that are already recorded to recompose the sentence digitally and reacts by writing and/or by answering. The speech detection or voice control applications contain some key expressions that can be useful and practical for the user such as 'call home' or 'sleep'.

This interaction method is used in several areas such as the 'in-car system', in health care, in military, education, disability applications, consumer electronics' and in many further applications.

Nowadays, the cars contain voice control applications usually activated by the touch screen control panel. The driver can use simple commands such as phone call, select radio stations, and play music via an external device or to start the navigation. Some of the most recent cars offer the possibility of a more natural interaction by detecting the complete sentences.

In the healthcare applications, the voice control is used usually for the medical documentation. It basically has two types of interaction: "front-end" and "back-end" recognition. The front-end interaction is to dictate the words to the device to create a new document, while the user (the doctor usually) can make changes on the screen after. The back-end interaction serves to find the documents from the digital archive by the detection of the keywords through the system.

In military, this technology is used for the "high-performance fighter aircrafts", "helicopters" and "training and traffic controllers".

In education, the speech recognition is useful for learning a language. To do practice or learn the right pronunciation, the voice control technology is a new and efficient way.

The students who are blind or who have difficulties about vision can get the benefit of this technology. It's a nice opportunity for them to hear the words and repeat them to learn spelling, punctuation, counting etc.

It is also useful for people who can not use the hands. They can control almost everything by vocal commands without difficulty.

The speech perception researches are started in 1932 by Bell Labs Researchers.
Raj Reddy, in the late 1960's, was the first person who made a continuous speech recognition performance as a student. The previous systems and trials were requiring a pause between each word, while the performance of Reddy was the first example of the recognition of a whole sentence. The 'Speech-to-Text' applications are started in 2000s by DARPA by the participation of

In terms of performance of the voice control systems, there are two main properties that are important: 'accuracy' and 'speed'. However there are many constraints that decreases the performance related to these two factors. Some of these constraints can be listed as:

1. Vocabulary size and variability: It is hard to manage the vocabulary of the speech if it contains confusable words or expressions

2. The speaker of the device: The number and quality of the hardware affects the perception quality.

3. Type and quality of the speech: Isolated, continuous or discontionious speaking affects the accuracy.

4. Language constraints

5. Reading vs. speaking: It is easier to detect the words than the natural speaking, while the voice is monotone.

6. Inconvenient conditions: The noise of the environment is an important factor decreasing and sometimes cramping the perception of the desired sound.

Because of these numerous constraints, the use of the voice control systems is not as much as expected. Especially the voice command software implemented in consumer electronics didn't make the expected success. However it is still in use within the recent devices and technologies.

2.3-5. Mobile Applications

The app-controlled product and system designs are getting more and more popular in industrial design field. Connectivity becomes an important feature for industrial products and the contemporary designs are mostly connected to a mobile application.

By the use of the mobile apps, the user is able to control and run the devices at home –such as kitchen appliances, security systems, TV etc. - remotely. This opportunity is advantageous because of its speed, ease of use and the adaptation of all the products to the user habits coming with the new modern life.

Most of the smart appliances and product provide the mobile applications connected to the product by Wi-fi connection. Some of these connections are based on Bluetooth technology, but these devices are getting 'old' within the fast development of technologies. The recent smart products are using mostly the Wi-fi connected mobile apps.

While the brand or company can provide their own mobile application for the specific product or service, there are many applications that the user can connect all of his own smart devices to a single software and can control all the devices by using a single application for the whole house.

fig. 2.11

2.4- A Study on the Implementation Of Interaction Into The Product Design

The development in digital world is affecting the daily life dramatically. The digital technology is being implemented in daily products cleverly, to enhance their performance and interactivity. The book 'The Invisible Computer' by Donald Norman is based on improving that technology has been seamlessly penetrated in the human life. The idea of using the digital elements as the basic component of product design became a natural behavior to achieve the high quality level of performance and experience.

Product design (or industrial design) is a field that aims offering optimized services in terms of "functionality", "usability" and "aesthetics" to the user. These three terms are the basis of product design field and have a big importance for the designers' working path. The 'functionality' has to be developed and optimized to offer ease in use, security, speed or practice to the user. The 'aesthetics' are important for attracting the attention of the client, so this is more for the marketing. And the 'usability' is the part that is the most related topic with the user, which takes the 'human' aspects in consideration. Here, the terms 'shape', 'function' and 'knowledge' have to be defined with their places in the design field.

The usability of the objects can be based on the "shape", and this is also related to 'ergonomics'. It is important for providing the comfort during the use of the product. Another side of usability comes from the "function". As strong as the functionality, the usability increases. The most important aspect in product design is to bring a new and innovative function to the product. And the last matter in usability is the "knowledge". For the user, the knowledge about the use of the product means ease, and most of the users prefer to choose the objects that are simple in terms of use. This is provided by "designing the interaction".

Interaction is the most significant way to enhance the product design. It is basically the way how the 'human' can use the product. It adds value on design and it enhances the experience for the user. In interaction design 'human' is in the center and everything is designed for him. This is called 'goal-oriented design' and is defined as 'designing to satisfy the needs and desires of the people who will interact with the designed object'.

Today, industrial design is a field that makes more than defining the physical features of a product, but it takes the needs and expectations of the user in order to build an interactive system. Furthermore, the design has to be able to link the physical and digital features together, to enhance the performance of the physical aspects by using digital interaction, and vice-versa, the physical properties of the object has to improve the quality level of the design of interaction.

Gillian Crampton Smith declares that interaction design is still at the level of the early stages of cinema. There is a need of a language that directly concerns to interactive technologies and interaction design. This means that the current applications are still within the previous creative modes and he created a set of categories that may be helpful to understand the languages of interaction design.

The four dimensions of interaction design are first created by Gillian Crampton Smith in the book 'Designing Interactions'; later, a fifth dimension is added by Kevin Silver:

1. 1D Words: The words are the tools for the interaction of people between each other.

2. 2D Visual Representations: The graphics such as typography, images, diagrams, icons etc. that the user interacts on an interface.

3. 3D Physical Objects and Spaces: The user interacts in the thirds dimension. This includes tangible and visual interaction.

4. 4D Time: This includes the interactive aspects that change by time such as 'music, videos or animation'.

5. 5D Behavior: This is the actions of the user in reaction to the interface.

The core principles of industrial design overlap with those of interaction design. Industrial design is created by using the knowledge to create an object combining form, color, aesthetics, user needs and desire and usability. Interaction designers and product designers are both informed through the cycles of user research. Both design areas take the user in the center and make studies on him. These studies are used to identify the needs and behaviors of the final user. The goal of the design process is to achieve the experience, usability and the influences. The designers both come up with conceptual ideas and aim to realize them by making strategic decisions.

However, there are some differences in terms of 'thinking'. Product design as mentions in the name is a field that concerns to 'physical' objects and products. So the thinking of a product designer is mainly about the 'mass' that will be designed. Interaction design is more about the 'behavior' which is relatively more abstract and intangible. So product design is more focused on the physical product, while interaction design works on the person who will use it.

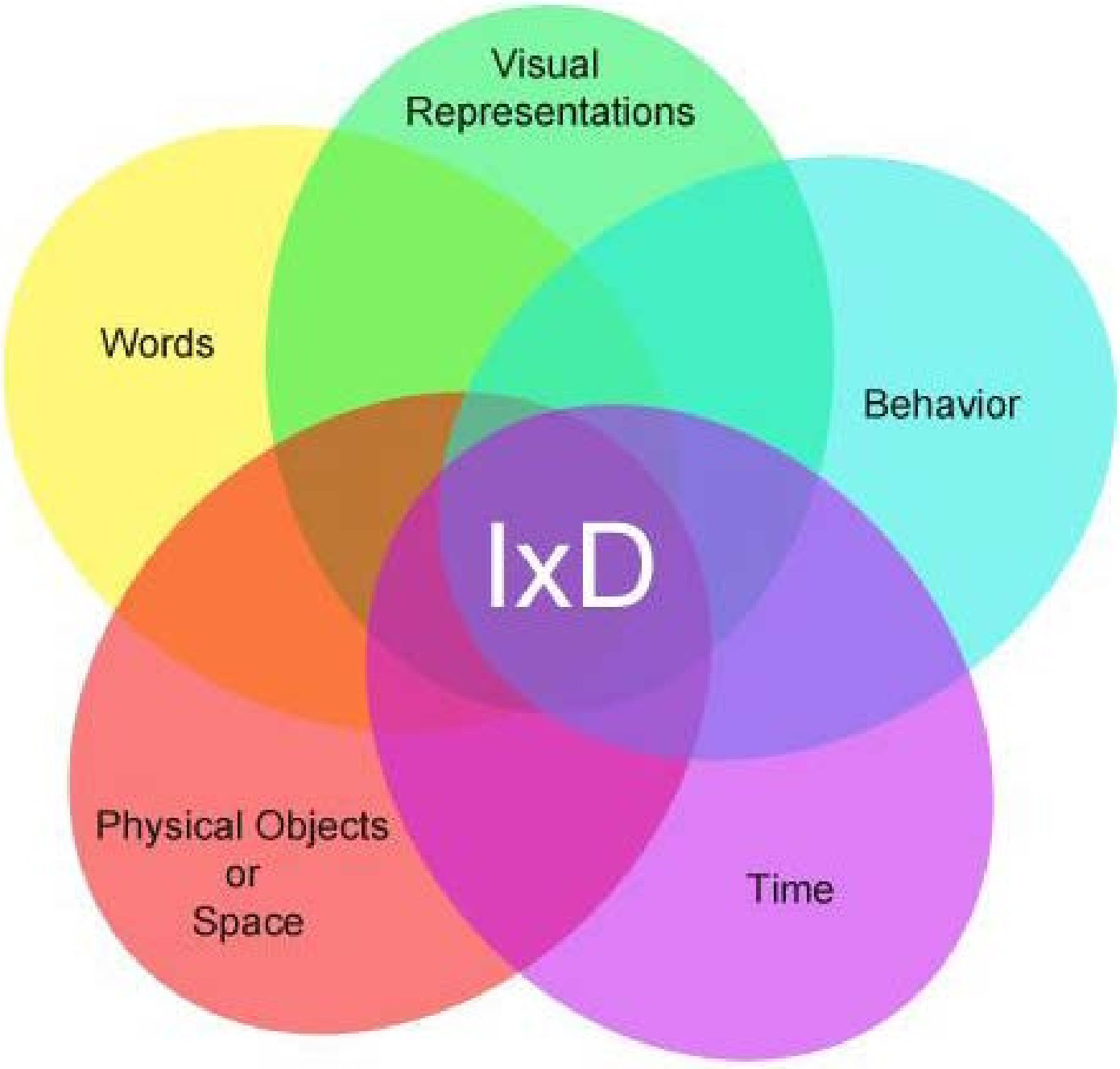
While the concept and strategy of two design field are different, interaction design can be a part of product design by some methods to be used. First of al, interaction design is not an area that uses only digital inputs to create an experience, the interaction can be made also physically. But the integration of interactions into product design can be realized more easily by the use of technology. The control of a product can be implemented in an easier way by using electronics. These technologies have different variations, while the most popular ones are; UX and UI.

As mentioned within this title, interaction design is important to improve the usability of a product design. However, there are many aspects that have to be considered, such as the placement and dimensioning of buttons, the graphics that are used, the menu interface etc. An inefficient or wrong use of such features may cause a "fail" instead of enhancing the quality of the design.

An inappropriate interaction may decrease the functionality and efficiency of a product. For example, the use of a touch screen for cooking equipments can be an obstruction for the control with dirty fingers, or the touch screen can activate some functions accidentally because of a drop of oil jumped onto the touch screen. So, the use of the digital or electrical components has to be defined accurately depending on the specific application for success in integration of interaction into product design.

This has also a psychological side. The in-house and outdoor users may have different expectations and psychologies and this affects mostly the 'feedback' part of the interaction. The sounds, visual signs, vibrations and other feedback solutions have to be studied and selected precisely, to create a correct effect on the user.

In summary, the quality and properties of the products and services are depending on the way how the designers choose to enter in communication with their customers. A good design is the product or service that is easy to understand. This understanding can be provided by the designer via the design tools that are mentioned as the 'five dimensions' of interaction design. The product designer has to be aware of these guides and use them as tools to enhance the quality of his designs. The design of interaction defines the capacity of the design and designer to communicate with the user.



2.5- A Study on The Implementation Of Interaction Into The Lighting Design

The main aim of lighting design is to provide light in the environment. For this, the functionality has to be the main aim for a designer. However there are many traditional and modern ways to control a lighting fixture and these controls are basically the interaction of the lighting design.

The interaction of the object is about the choice of the designer but mostly related to his/her observations about the users' habits. It's important to offer a product convenient with the life style of the user, while it is vital to create interactions that the user can deal with easily. In some cases such as entertainment, it may be better to have a more complicated interaction. But usually, for daily uses, the simpler interactions are more successful to integrate naturally in the current life of the user.

In this thesis, a variety of methods to interact with a lighting element are studied in the next chapters. Some of these methods are very simple such as turning a light on or off, while some others can be a bit more complicated and innovative. All these are related to the use of technological components and techniques implemented in the product itself, or in the lighting control systems.

The conventional use of interaction design in lighting is generally about the efficiency of the light. The control panels and remote controllers used for big spaces are the primary examples of the functional interaction. By using these techniques, a big area can be controlled piece by piece and these parts can be switched on/off, dimmed and colored manually as these features can be realized by sensors, according to the daylight for example. Besides the external conditions, the light can be adjusted according to the mood or behavior of the users. By using different devices, the user is enabled to create his own lighting environment.

More than being turned on/off, a good lighting design has to answer the needs of the user. A good lighting design may have to be flexible for different applications, while it can have a single function with high efficiency. The position, direction, angle, diffuseness and such aspects of a light are important to create the right lighting environment. The lighting control systems and methods aim to offer the user the possibility to personalize their environment by different interactions.

The controls more than on/off functions affect the physiology and psychology of people. As different activities need different lighting, differently lightened environments create different effects on the user. The role of the designer here is to offer the user the ability to find the right lighting for him.

By using interaction design, the lighting fixture can solve a specific problem, answer a need of the user or provide fun in his experience. For functionality, the lighting designer has to observe the user well, define the specific problems and implement technologies in an efficient way.

As the interaction can be implemented into a lighting system for functionality, it can be a way to create daily entertainmental activities for users. The automated systems using color, dimming, animations and other features, are great for creating interactive environments for domestic uses. In this kind of interaction design, it is important to maintain the design tools well, such as advanced visualization techniques. These techniques can be exemplified as real time rendering, 3D graphics, projection methods etc.

As a lighting fixture is a product itself, the five languages are still valid as tools for design. While in this case the '1D Words' may be not very useful, the other four matters can be useful guides for lighting design. The visual representations (2D) are perfect to create different atmospheres. The visual and tangible interactions (3D) contain the ways to control a lighting design. These are the basis of lighting design interactions. A lighting design changing by time is a very useful feature to adapt the lighting to states of the daylight, for example. The behavior of the fixture or light is the highest and the most interesting level of lighting interaction, which is partly implemented in 'Luvi', which is the new design work of this thesis.

Finally, it is obvious that interaction design is very important to increase the efficiency and effects of a lighting design for the user, it's the basis of a human-centered lighting design process.

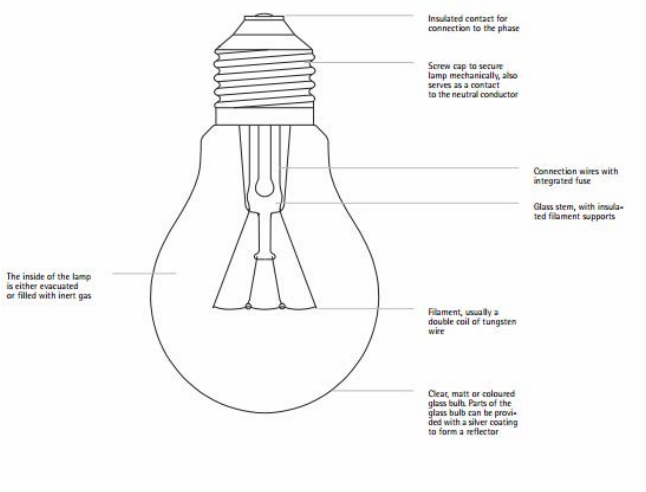
CHAPTER 3:
LIGHTING TECHNOLOGIES

A research on light types and technologies as a guide for light type selection for the new design

3.1- Light Sources

3.1-1. Incandescent Lamps

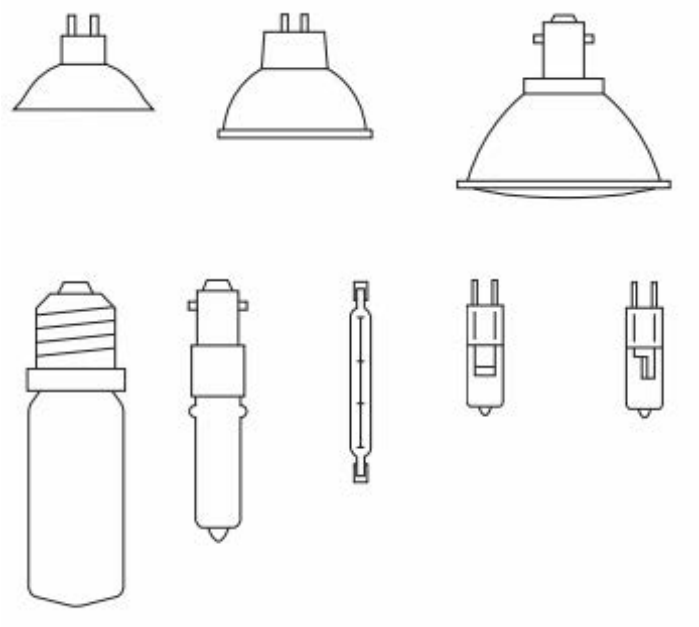
The incandescent lamp can be defined as a thermal radiator. Its working principle is based on the increased temperature by an electrical current to the sufficient heat for shortening the wavelength range of the radiated light. By this way the red colored heat filament becomes a warm white light color. Depending on the type of lamp, the heat can reach up to 3000 K (2726.850ºC).



To increase the temperature enough, it is necessary to use the right material for the filament wire. Lack of suitable wire avoids to achieve the right temperature and to get light. The most suitable materials are good in electrical conductivity and it is required to have a sufficiently high melting point and minor evaporation rate. Nowadays, the most common material used for incandescent lamps is 'Tungsten' because of its low melting point (3653K) and low evaporation rate.

Incandescent lamps can be dimmed easily without the need of a control gear. The light color produced by incandescent lamp is warmer than the daylight, while they have a low color temperature. The continuous color spectrum of incandescent lamps provides an excellent color rendering.

As the incandescent lamps have many advantages, they have also some disadvantages. Their luminous efficiency is low and there are some special variations to solve this problem. However these types can only increase the efficiency up to 40%.



The incandescent lamps can be produced in many shapes and sizes. The glass can be clear, matt or opal. These features makes possible to create special forms for critical applications, while a variety of shapes and colors are available for decorative purposes.

Halogen lamp is a type of incandescent lamps. They don't require too high melting point as Tungsten incandescent lamps, 2800K is an enough temperature. The principle of this type is to add an amount of halogen in the gas mixture with the aim of preventing the blackening of the glass shield. This avoids different temperature on the inner and outer parts of the lamp and removes the possibility of blackening while increasing the efficacy.

3.1-2. Discharge Lamps

In contrast with incandescent lamps, the discharge lamps' principle is to stimulate the gases or metal vapors. This is realized by applying voltage between two electrodes located in a discharge tube filled with inert gases or metal vapors.

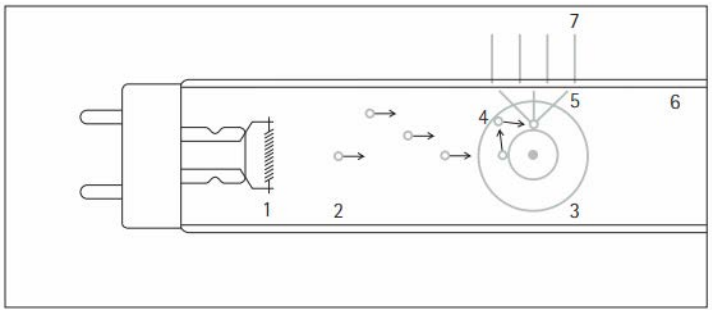
The main difference between the incandescent and the discharge lamps is the type of the spectrum. Incandescent lamps have a continuous spectrum while the discharge lamps produce a spectrum with narrow bands. These spectrum lines can produce a range of light from infrared until the visible region of ultraviolet.

The quality of light can be changed by the pressure of the gas or metal vapor in the discharge tube. By the increase of the pressure, the quality of the color rendering increases as well.

The discharge lamps can be divided in two main families: the 'hot-cathode' and 'cold-cathode' lamps. These are related to the temperatures to be operated in. On the other hand, there are three types of discharge lamps, categorized depending on the applications and usage purposes. The high intensity discharge lamps are typically used when very high levels of light and energy efficiency are desired. The high pressure discharge lamps are preferred for the applications requiring high resistance to pressure. The third category is the low-pressure discharge lamp that is also called 'Fluorescent Lamp'.

fig. 3.1

3.1-2.1. Fluorescent Lamps



The fluorescent lamp is a low-pressure discharge lamp using mercury vapor. It has a discharge tube with an electrode at each end. The gas used to fill the tube contains an inert gas, which blazes easily and controls the discharge, additionally a small amount of mercury, which produces ultraviolet radiation by its vapor. The inner surface of the discharge tube is coated with a fluorescent substance that transforms the ultraviolet radiation to the visible light. The wire of filament is usually coated with a metallic oxide to provide ease in blazing.

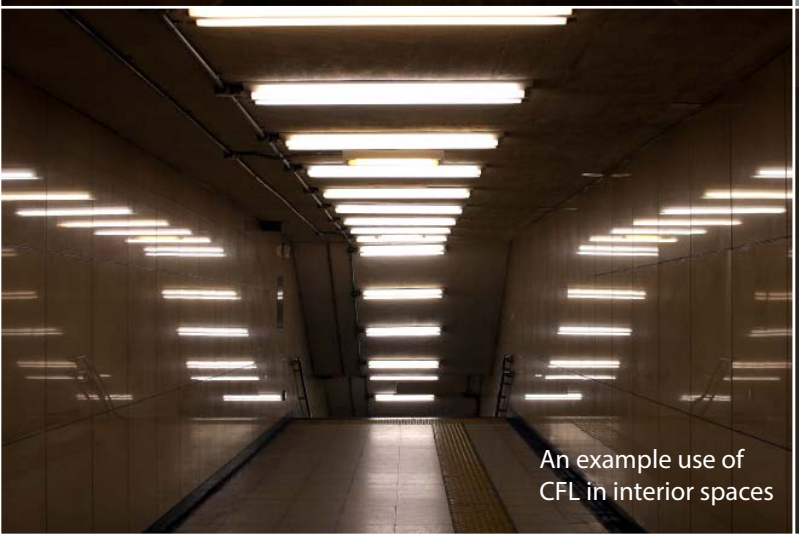
Differently from incandescent light sources which create point light, the light created by the fluorescent lamp diffuses in a larger area. This diffuse light of the fluorescent lamp gives rise to soft shadows. This light avoids glaze or sparkling effects on glossy surfaces.

The fluorescent lamp has a non-continuous spectrum in contrast with the incandescent lamp, which means different color renderings than the incandescent lamp. It is possible to create white light with different color temperatures, but the color intensity of fluorescent lamp is always poorer.

Fluorescent lamps have long life cycle and they are usually in a tubular shape. U-shaped or O-shaped variations are available as well.


A U shaped Fluorescent Lamp


An application of a circular CFL in lighting design *by Taylor LEVI*


An example use of CFL in interior spaces


An application of CFL in lighting design *by Plumen*

3.1-2.2- Low Pressure Sodium

This type of lamp is the most efficient lighting source available. It is a monochromatic lamp, providing a yellow light. Its main usage areas are the exterior and street lighting because of its economical benefit, its efficiency may be up to 200lm/watt. This kind of lamp cannot be used in interior spaces.

3.1-2.3- High Intensity Discharge (HID)

There are three main types of the HID lamps. These are High Pressure Mercury lamps (MBF), Metal Halide lamps (HQI) and High Pressure Sodium (SON) lamps.

The High Pressure Mercury lamps have moderately higher efficiency. It is generally used in street lighting and automative thanks to its long life span and long-term economical benefits. They give a light color in purple, yellow, green and ultraviolet wavelengths that brings a 'blueish' cold white light.

The Metal Halide lamps use a gas inside to create a wider light spectrum. This halide gas increases also the efficiency. This lamp type can be an answer to many needs of lighting such as; the efficiency, variety of sizes and shapes of bulbs, long life and wide color temperature range. However it has a big disadvantage which is its high cost. There are other negative aspects such as a need of a big and bulky control gear, limited dimming options and long time period for warming up and restriking. The color shifting problem occurs also for this type of lamp.

The High Pressure Sodium lamp is based on the higher pressure. This allows a better and high quality color rendering and appearance. But in this case, this lamp has a problem of creating

3.1-3. Tungsten Halogen Lamps

The tungsten halogen lamps (TH) are basically a type of filament lamps composed of a quartz glass shell containing an amount of halogen gas. The role of the gas is to allow operating at high temperature with higher pressures. The normal glasses do not transmit the UV light while the quartz glass transmits at a significant level. This is important to understand the usage areas of the TH lamps.

The color of the light created by a tungsten halogen lamp is cooler than a standard incandescent lamp (3000K), but this difference is not noticeable, the lamp is still giving a warm ambiance to the environment. The tungsten halogen lamps have a double life time comparing to the standard lamps (incandescent and discharge lamps) while its efficiency is also much higher than others; it has an efficiency up to 22lm/watt.

Despite the development of the technologies in lighting field, the tungsten halogen lamps are often chosen for their color, their simplicity of operation and their ease in dimming, even if there are a lot of different lighting sources with higher efficiency, longer life and lower cost.

The filament of the TH lamps has a high degree of control, so that it can be projected from greater distances with greater accuracy. This makes the tungsten halogen lamp a suitable light source for displays, flood lighting, wall washing and uplighting.



3.1-4. LED Lamps

LED which means 'Light Emitting Diode' is a semi-conductive light emitting electronic circuit. These light sources were capable to give a poor red light before, but nowadays there are many applications and variations of this technology, and they are able to produce light with a very high intensity.

The basic properties of LED lamps can be listed as:

1. They are semi-conductive circuits.
2. The main material of LED is 'silicone'.
3. They expose photons –which mean light particles, when a current passes through.
4. They are able to give light at different angles.
5. They are voltage sensitive. This requires serial connections to avoid big changes in voltage.
6. They produce light in three main colors in RGB system. By mixing these three colors red, blue and green, it is possible to obtain different colors.
7. The voltage for functioning varies depending on color:

    a. Red LED: 2,20 Volt
    b. Green LED: 3,30 Volt
    c. Blue and White LED: 3,40 Volt

It has been possible to use the LED efficiently by the availability of blue color in the RGB system, and this made the usage of LED lamps possible in a variety of applications in many sectors. Signalization and architectural lighting are the main application fields of LED.

LED technology's the biggest advantage is its low consumption level. This implied the increase of preference of LED comparing to the other light sources because their loss of energy is minimal. They also have a very long life cycle.

The LED technology has a lot of benefits while it has many drawbacks too. The advantages can be listed as below:

+ **Energy efficiency:** They are able to produce 135lumens/watt
+ **Long lifetime:** They can be used 50.000 hours or more by a good engineering
+ **Rugged material:** They use solid material avoiding filaments and breaking of tube or bulb.
+ **No warm-up duration needed:** They start immediately when turned on.
+ **No affection of temperature:** They can be used in any temperature, even subzero environments.
+ **Directional lighting becomes possible:** By LEDs the light can be directed anywhere desired, without a loss of energy.
+ **Excellent color rendering:** They are perfect for displays and retail applications.
+ **Eco-friendliness:** They do not contain mercury or hazardous substances
+ **Controllable/adjustable:** LEDs can be adjusted for brightness and color.

The biggest advantage and reason ofpoularity of LED lamps is the low electricity consumption and relative eco-friendliness.

It's also important to understand the reason why the LED technology is so popular and they are chosen for many applications. The first reason can be the possibility to turn on and off the lamp very frequently. It is not possible with many other lamps such as the fluorescent lamps that get warm very quickly. Secondly LED is a light type allowing to dim the light easily. This can be very important for a lot of applications, while it provides ease in many design processes as well. Then, they light up very quickly, which is very important from the choice of the final users. A typical red indicator can achieve the full brightness in microseconds.

It is difficult to damage an LED light bulb by an external force unlike a fluorescent lamp or an incandescent light bulb. The LEDs can be very small and be populated very easily.

However, this technology has many disadvantages and challenges in use. First of all, they are much more expensive comparing to the conventional lighting techniques. They have some technical constraints such as the need of a correct voltage and current at a constant flow. To design the electronic drivers, it's needed to have an electrical expertise. The performance of the LED may strongly depend on the quality of engineering. The 'color shifting' is also an important factor. The LED light can shift color because of the age and temperature. And also, the color of two different white LEDs will be different because of different color characteristics, while this highly affects the perception of the color when combined.

3.2- Comparison of the light types in terms of functional and ecological efficiency

In this part, the light types will be compared in terms of life span average, electrical consumption, annual operating cost, environmental impact, some important facts and the light output. The light types will be categorized in three main topics depending on the popularity in use; incandescent lamp, fluorescent lamp and LED will be compared below.

3.2-1. Life Span Average

In this category, it's obvious that the LED light has the longest lifetime comparing to the others. Its average life is 50,000 hours, while the incandescent lamp has 1200 hours and the fluorescent lamp 8000 hours. This difference creates one of the biggest benefits of the LED technology.

3.2-2. Electrical Consumption

LED uses less power (watt) per a unit of light (lumens). Its value is between 6 – 8 watts/lumens. LEDs help to reduce greenhouse gas emissions from power plants and this value brings lower electric bills. The most consuming light type is the incandescent with the value of 60 watts, while the fluorescent lamp is between these two types but nearer to LED. It has a consumption of 13 – 15 watts/lumens.

3.2-3. Annual Operating Cost

The operating costs vary a lot depending on the technology. The cost of an incandescent lamp is 10 times of the cost of an LED. The operation of the LED light bulbs cost 32.85$ per year while the cost of the incandescent lamp is 328.59$. The fluorescent light is again at medium level with an operating cost of 76.65$.

3.2-4. Environmental Impact

Level of TOXIC Mercury Content

LED and the incandescent lighting technologies do not contain any toxic mercury. So they are not dangerous for human healt and the environment. However the fluorescent lamps contain a high level of mercury which creates a big threat for the human health and also for the environment.

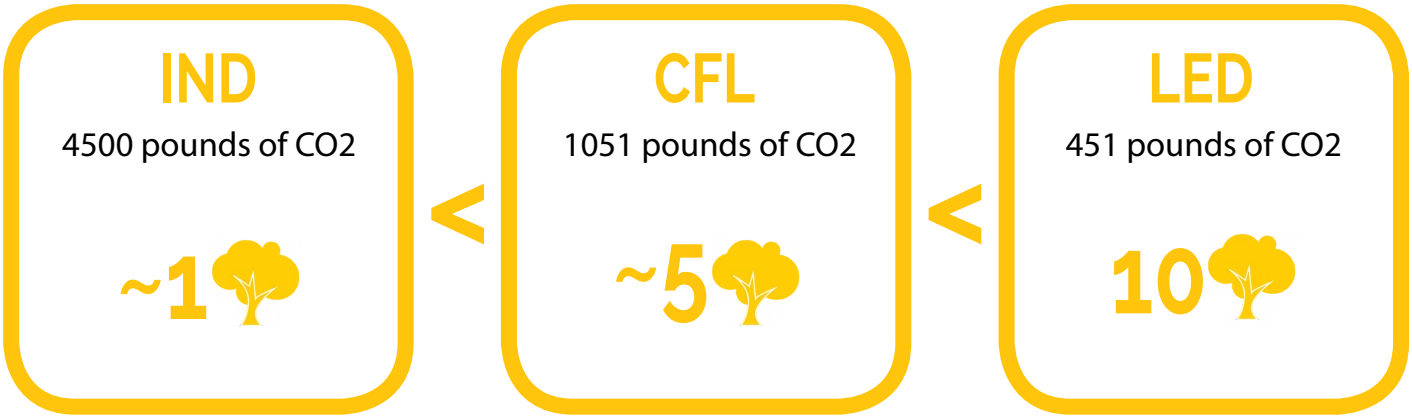
RoHS Compliant

RoHS is a directive that stipulates to avoid the content of some toxic materials in the structure of the electrical boards and materials. It is composed of the first letters of 'Restriction of Hazardous Substances Directive'.

In this case it is observed that the LED and the incandescent light bulbs are convenient with these restrictions, while the fluorescent lamp contains 1 – 5 mg of mercury being against with the directive and eco-friendly principles.

Carbon Dioxide Emissions

This stage is very important for the human health and the environment. However, it is observed that the lower energy consumption level brings decreasing level of CO_2 emissions, sulfur oxide and high-level nuclear waste. The numeric values show that the incandescent lamp has an emission of 4500 pound, the fluorescent lamp has a value of 1051 pounds and LED has only 451 pounds of carbon emission per year.



3.2-5. Important Facts

Sensitivity to Temperature
The fluorescent lamp is the most sensitive lamp to the external temperature. It may not work under -10 degrees Fahrenheit and over 120 degrees Fahrenheit. Some of incandescent lamps may be sensitive to temperature, while none of the LED lamps have a sensitivity.

Sensitivity to Humidity
The only type of light that doesn't get influenced from water and humidity is the LED lighting. The incandescent light bulbs have some variations that are humidity resistant, while some types are sensitive. The fluorescent lamps don't have resistance to humidity.

On/off Cycling
Switching a CFL (Compact Fluorescent Lamp) on/off quickly in a closet for instance can affect the life span of the light bulb. There are variations of incandescent lamps that show the same character, however the incandescent lamps have a resistance to cycling in general. The biggest advantage of LED is the long lifespan thanks to the resistance to a large number of on/off cycling.

Instant Start
The incandescent lamps and LED light bulbs are the most preferred lighting systems for domestic uses because of their speed of start. These kinds of lamps can start immediately when they are turned on. However the fluorescent lamps need some time period for efficient lighting power. They need some time to warm up.

Durability
The incandescent lamps and the fluorescent lamps are not very durable. The filament or the glass of an incandescent bulb can break easily, while the glass of the fluorescent lamp is not very strong as well. However, the LED bulbs have a strong structure, they are very durable and they can even handle jarring and bumping.

Emitted Heat
The heat is very important for the safety during the use. From this point of view it is observed that the incandescent lamps are not safe anymore. They create 85btu's per hour. The fluorescent lamps emit much less heat than incandescent lamps with a value of 30btu's/hour. However the LED has a very low average of heating. They emit 3.4btu's per hour which is a very low value. So, this means that the LED lighting is successful also for safety.

Failure Modes
The LED light bulbs do not have a typical failure mode. The failure of an LED is not very common but it can be observed in some cases with different failure modes. The incandescent lamps are more sensitive and fragile, so they have some typical cases of failure. But the fluorescent lamps have some known and typical failure types that can be defined as catching fire or smoke and omitting some odors.

3.2-6. Lighting Output

The lams that are used for lighting are usually tagged with their light output in 'lumens', and in many cases this is restricted by the law. So, for example a 23W fluorescent lamp emits around 1400 – 1600 lumens. Many types of lamps are defined by their equivalence to an incandescent by a specific wattage. For defining this wattage there is a standardization table used by the engineers, shown below.

Minimum Light Output (lumens)	Electrical Power Consumption		
	Incandescent	Fluorescent	LED
200	25	3–5	3
450	40	9–11	5–8
800	60	13–15	9–12
1100	75	18–20	13–16
1600	100	24–28	18–22
2400	150	30–52	30
3100	200	49–75	32
4000	300	75–100	40,5

As a result of the Eco-Design Directive for Energy Using Products (EuP) launched by the European Union, it has been mandatory to label the electrical lighting components by the luminous flux (lumens) instead of electrical power (Watt). This table is then constructed and accepted on September 1st, 2010 by European Union committee. This directive requires that an energy-efficient light bulb which is equivalent to a 60W tungsten light bulb should have a light output of 700 – 750 lm in minimum.

3.3. Contemporary Lighting Methods

As the management and design for profiting from the daylight is a critical issue, it is necessary to use the artificial lighting. Nowadays, the technology changes and develops very quickly and there are several methods and possibilities for interior and exterior lighting design.

For interior lighting there are some important factors for the design of the lighting fixture. These crucial aspects are the size, the lifespan, efficiency, energy use, color and temperature, control capacity and cost.

The efficiency and lower energy consumption are the most important factors when choosing a lighting source. For example, the consumption cost of an incandescent lamp is 5 to 10 times of the price of the bulb itself. So, nowadays, by the new technologies, the incandescent lamps started to lose their popularity.

The efficiency and ecological side of the lighting sources directs the users to choose mostly the LED and the CFL lamps. However the CFL lamps are less durable and their life span is much less than an LED lamp. The waiting time period of these lamps is another disadvantage. With these negative points of CFL, LED looks advantageous in terms of preference. By the way, these two are the most popular light sources for the current applications.

As the CFL is more expensive than the LED, it is preferred for big buildings and also exterior applications because of its natural cold white color. It is easy to manage and maintain and easy to provide. From this point of view, for mass-applications, fluorescent lamps look more advantageous.

LED lamps are easy to find and built. They have a lot of possibilities in terms of color, size, combinations and application areas. They became very cheap and easy to find. So, undoubtedly, LED became the most popular lighting component of the time.

3.4. Lighting Control Systems

3.4-1. On/off Buttons and Switches

This method is the most traditional and simplest way to control a lighting element. The principle is to conduct electricity when turned on and break the circuit when turned off. The level of electricity is 1 or 0. No values between these two are provided.

These components are still popular and used for many applications. They are popular in domestic uses and lighting design because of the simplicity of interaction and also for machinery and other specific uses by providing a high level of security.

These control elements can be designed and produced in a variety of shapes and colors, depending on the application, function and aesthetics. They can be used connected to all types of lamps without a restriction of voltage.

The multi-way switching allows the control of a lighting element from two or more points, controlling the lighting of a corridor or a stairwell from the two ends. A remote switch can be used for controlling a lamp wireless, while a touch switch provides control by touching anywhere on the switch. Nowadays there are a lot of applications of the switches for many different applications.

A switch can be designed to be single or multiple. The usage area may depend from indoor to outdoor environments and these may require environmental protections, weather and security protections related to the design.

The material used for the shell of the switches is usually a sort of polymer. Inside there are the kinds of metals that are used for connections while the most popular one is copper.

In internal lighting systems, the switch directly controls the current of the lamp to turn it on or off. However the bigger lightings such as big buildings or outdoor lighting requires the use of a relay in order to allow manual control for the light.

The most important role of design here is to make the transition as rapid as possible. For this, the usage of a spring would be a helpful operation. The potential energy required will be stored by the spring and when the mechanical energy is sufficient, the mechanism in the switch breaks over and the transition from open to closed will be realized as quick as possible. This quick breaking action provides a longer lifespan for the switch and this is proved and patented by Holmes in 1884.

It is important to make a switch safe. The safety of a switch can be provided by holding the contacts firmly together, in the position of the switch when it's off. By this way, regardless the quality of operation, the switch will be turned on and off quickly.

There are many variations on the design of a switch. One of them is the 'push buttons'. These switches are based on two buttons that relatively turns the light on or off by the pressure applied by the user. The 'toggle' mechanism provides a snap action through an over center geometry. Here the actuator doesn't control the contacts directly but the control is realized by springs and levers. The 'rocker switch' is the most common application in domestic use and it's a variation of the toggle.

fig. 3.2

3.4-2. Dimmers

A dimmer is basically a linear or rotary knob that will be moved from a starting 'zero' point towards 100% position to adjust the intensity of light accordingly. While the dimmers remain to be an important tool in lighting design, it started to become only an item to for controlling a lighting element. The revolutions in computer science and micro-controllers brought several new ways and approaches for the control of the light.

In reality, the aim to use a dimmer is to avoid sudden jumps of power by providing the light intensity to change in a linear way. The tools generally used for dimming the light are a control knob or a slider. This method's accuracy and linearity is acceptable for domestic uses.

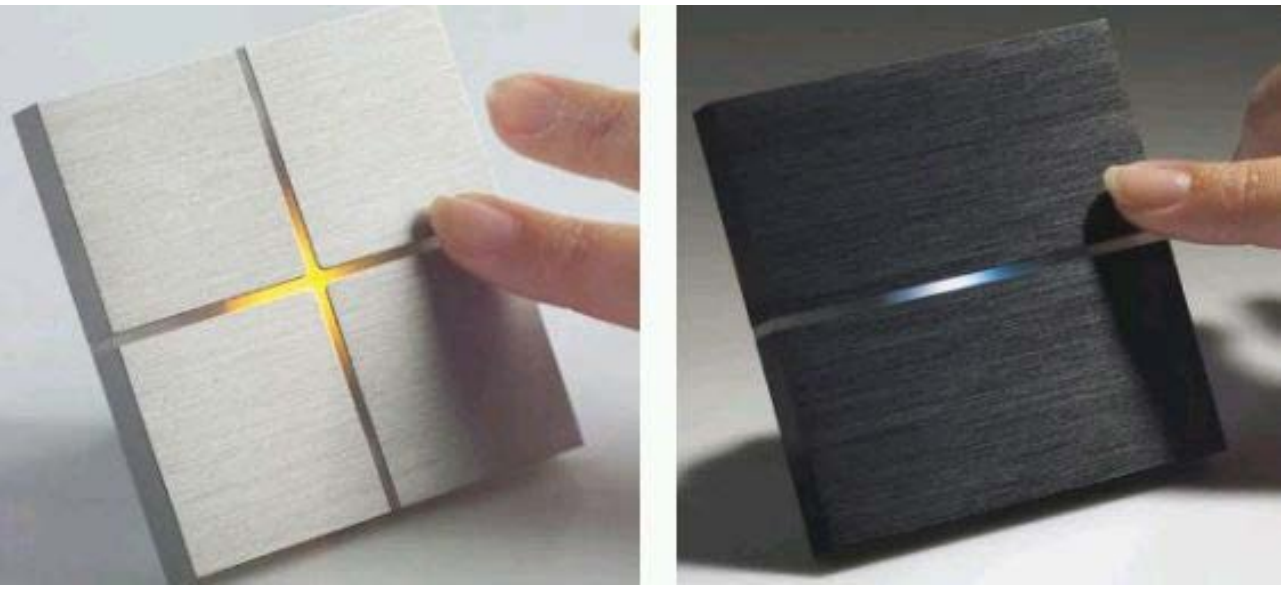
Dimmers today are coming up with a variety of styles and designs, and they are able to control many different types of loads. This brings an advantage especially for big buildings that may use different kinds of lighting elements together such as fluorescents, incandescent and discharges combinations. This kind of combinations requires a proper matching of control systems while most of these require different types of dimming devices. It is not possible to use a wall-mounted dim controller for each type of lamp, for example. The incandescent controllers have many types of dimmers for control: standard voltage dimmers (600W, 120V), high wattage dimmers (1000 to 2000W), low voltage magnetic dimmers and low voltage electronic dimmers are some examples. To handle higher voltages it may be needed to use a remote dimming device, which is not mounted on the wall.

The biggest offer of the new technology dimmers is the possibility of 'presets'. This allows the user to set the light intensity of the desired area only, and to use a single command for the dimming of a group of spaces and lamps. This aspect creates a big opportunity for the product and interaction designers to create moods or scenes to be performed by a single touch. This presetting system can offer big chances to create control of multiple switches by groups in big spaces and environments. This is a technology allowing the designer to create 'scenes' for a variety of fields from security to entertainment applications.

The dimming of incandescent lamps influences the costs of maintenance. There are some systems to avoid instant start and sudden jump of electricity by a 'soft start' to increase the life span of the light bulbs. Some more sophisticated system makes the start by light fading, and this can increase the lamp life more than double.

A wrong thinking about the dimming system is the idea that this system can save energy. However a light dimmed to 50% of intensity is still using 75% of power.

The case of fluorescent lamps is a bit different. It requires a special planning and it is valid only for some kinds of fluorescents. The cost of fluorescent dimming has been decreased considerably in recent years, but it stills an expensive technology. The system of dimming has to be constructed at the stage of construction of the lighting system. Otherwise, to add dimmer on an existing lamp would add a lot of complexity. So, the dimming system installation has to be realized before creating the lighting systems of a building. Unlike as it's known commonly, dimming doesn't increase the lifespan of a fluorescent lamp.



Sentido Dimmer Switch Design *by Basalte*

Touch Dimmer Switch Design *by Viko*

3.4-3. Sensors

Motion Sensor Controls

Motion sensors are used to turn the light on or off when a motion is detected. They are useful for outdoor and utility lighting. With the motion sensors there are no needs of a physical interaction of the user. The light is controlled automatically.

These systems are useful to avoid people to stay in the dark and it is a good way to save energy because there is no possibility to forget the light on. The light is active only if there is a person.

The working principle of this system contains a switch for the first start. Once the switch is turned on, the light is on for a certain time, and it gets automatically of if there is no movement. After this stage the activation of the light is related to the presence of a motion.

There are some needs to use the motion sensor for lighting efficiently. These system requirements are:

1. Minimum light level in the environment for the ceiling lighting should be 40lx.
2. The motion should be realized within 5m around the lamp to be detected.
3. The sensor should be kept 10-15 feet away from heat, even from sunlight.
4. The motion direction should be parallel to the sensor. The sensors don't work efficiently when the motion is performed towards it.

There are a variety of motion sensors and these can be installed easily on an existing lamp without the need of an understructure and professional maintenance.

Occupancy Sensor Controls

These sensors detect the specific activities performed in a limited area. A simple example can be given as turning the lamp on automatically when a person enters in the room and turn it off if there are no actions for a certain time. These are useful for creating scenarios for new interactive designs.

There are two types of occupancy sensors called 'Ultrasonic' and 'Infrared' occupancy sensors. The ultrasonic sensors are able to detect the sound while the infrared sensors detect the motion and heat. These sensors are used in ambient lighting as well as they are useful for task lighting such as the use in kitchens.

The location and the detection area of the sensor should be selected carefully to provide an efficient interaction. However, as the detection area and accuracy of a sensor cannot be always perfect, these sensors have always been programmed with a delay before switching on or off. This delay for switch-off action can be up to 15 minutes. In this case, the light will be switched off 15 minutes after the last person leaves the environment. Some sophisticated systems switch the lights of by dimming, so that the light intensity is reduced gradually within the given delay time.

Photo Sensor Controls

The main aim of the Photosensor is to prevent the artificial lighting to be active when there is sunlight. This light sensitive system is less effective in indoor environments because the light has to be varied with the activity of the occupant but not the ambient lighting levels. However, there are many LED nightlight design application using this technology, and they become useful and easy to use with this technique. This method can be very useful for outdoor applications.

The first reason to use such sensors is to save energy by turning the electricity lighting off when the sunlight exists. The benefit of the automation is to realize the energy saving without the need of a human intervention. When combined with the other technologies such as dimmers, very nice effects and interactions can be obtained.

However some problems may occur in case of insufficient lighting or instant contact with light. As prevention, the location of the sensor has to be arranged well, to provide good and balanced lighting conditions.

Use of lighting with a conventional switch

Use of lighting with a motion sensor

fig. 3.3- The use of sensors in lighting makes the life easier.

3.4-4. Timers

Timers are useful to turn the lights on or off at a specific time that is planned before depending on the need. There are two types of timers. These are the manual timers and the digital programmable timers. The manual timers are plugged into an electrical outlet in order to control the lighting fixtures. The programmable digital timers are usually mounted on the wall; they automate the indoor and outdoor lighting.

The programmable timers are not suitable for the outdoor use alone, because they need to be changed according to the seasonal changements of the night time length. But this feature can be solved and enhanced by the usage of additional sensors. For indoor lighting this system can be very useful to create a lived-in look for an untenanted house.

As the timers do not work by interrupting the circuits they are very suitable for the use with CFL and LED light bulbs. Especially the manual timers are the best in combination with LEDs.

Chronological timing provides turning the lamp on or off at a specific time of the day as desired by the user. The astronomical timing is based on the control of outdoor lighting, to turn the lights on or off depending on the sunrise or sunset.

Time based intensity control is a method for saving energy. With this method, the user can set the intensity of the lights to be increased or decreased depending on the programming. This smart automation would be helpful for saving money, and also for creating scenes and ambiances.

3.4-5. Combining Control Schemes

Many offices, business and industrial buildings made success in using the timing systems for saving energy. Most of them combine the timers with occupancy sensors and manual switches so that the single offices and smaller sub-areas are able to be controlled independently. This system is called as 'The Backbone System' and it helps to handle more power for larger areas more easily. There are some key points to consider when creating a backbone system. These are;

1. **The capability of switching:** It is very important to have an understructure that is able to handle a fixed current, lamp attacks and possible defective current.

2. **The location of the sensors and timer:** The lighting control system's basis should be placed near the lighting panel boards.

3. **Maintenance:** The timer should be designed easy to change the schedule. It is better to create a flexible schedule that can be easily changed in case of unexpected holidays etc.

4. **Well-planning of the area:** The building or the whole area has to be divided in small zones in order to provide ease in control and saving energy.

The cost of lighting can be reduced by the right choice of control system and installation. This may also create a nice difference in the lighting effect of the building.

3.5. LED Lighting

3.5-1. Definition

LED (Light Emitting Diode) is a semi-conductor light source. It is a particular diode that generates light (photons) when a flow of electrons passes through it. To build a diode, a crystal which is basically an electric insulator enhanced by doping atoms has to be used.

An LED is usually small in area (less than 1 mm2). The early LEDs were used as small indicators for devices replacing the incandescent light bulbs which are much bigger. The recent developments in technology allow the LED bulbs to be used in environmental and task lighting. Nowadays they are used in many different areas such as automotive, advertising, aviation industry, general lighting, traffic signals, consumer electronics and decorations.

LED technology allowed the development of new text and video displays and sensors. LED light bulbs replaced the incandescent lamps in many areas thanks to their low cost and higher efficiency.

Some LEDs are produced tobe directly suitable to be replaced with the conventional incandescent lamps. Being similar to the incandesent light bulbs and different from the CFL bulbs, the LED bulbs don't need a warm up time tp reach the full brightness and the life cycle of the LED bulbs is much higher than these two other light sources. The advantages and disadvantages of using LEDs will be studied with more details later.

General purpose lighting applications need a clean white light similar to daylight. As the wavelength of the light emitted by an LED is naturally very narrow, it is necessary to mix the three main colors red, green and blue to get the true color. This mixing application and possibility makes the LEDs suitable for daily lighting apllications as well as for the uses with the need of sensitive light color. Recently, the conventional light bulbs have been started to be replaced with LED bulbs because of its advantages.

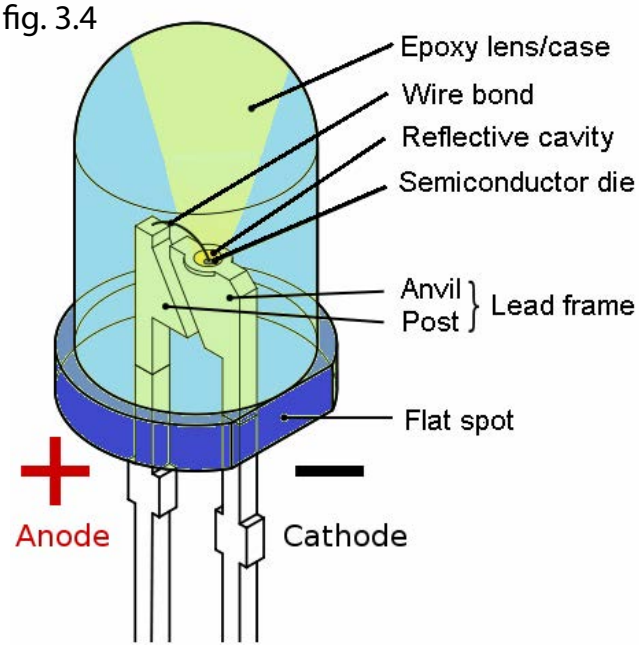
3.5-2. Working Principle

A common technical definition for the working principle of an LED is:

"A Light emitting diode (LED) is essentially a pn junction diode. When carriers are injected across a forward-biased junction, it emits incoherent light. Most of the commercial LEDs are realized using a highly doped n and a p Junction."

However, for a design point of view, this definition may not be explanative. So in this chapter, the LED technology will be analyzed in different ways. First, it is important to understand what a light emitting diode is.

fig. 3.4



An LED uses a technology called 'solid-state' or SSL. Basically instead of using the vacuum as the incandescent lamp or a gas as the CFL, it uses a piece of a solid matter to emit light. This solid matter is usually a semi-conductor material.

Very simply, an LED emits light by the movement of the electrons around within this semiconductor material.

The semiconductor die is made of two parts, one is positively and the other is negatively charged. The positive side has openings to allow the electrons and on the negative side the electrons are floating freely. A coming current activates the system through the semiconductor and the electrons start to flow from the negative to the positive side. This flow through the positive side provides the electrons to emit light. As the light is not produced by a filament, the bulb doesn't get hot and so, it is possible to use a polymer material for the shell, and this polymer is 'Epoxy'.

A semiconductor is a material that has a varying ability to conduct the electrical current. In the case of an LED, this part is called a 'diode'. Most of semiconductors are made of poor conductor materials that have impurities (this impurity is provided by adding atoms of a different material and this is called 'doping'), and in case of the LED this is usually 'Aluminum-Gallium-Arsenide' (AlGaAs). The pure AlGaAs has perfectly bonded atoms that do not leave free space for the electrons. But the doped material, the impurities change the balance and allows the electrons to create the flow.

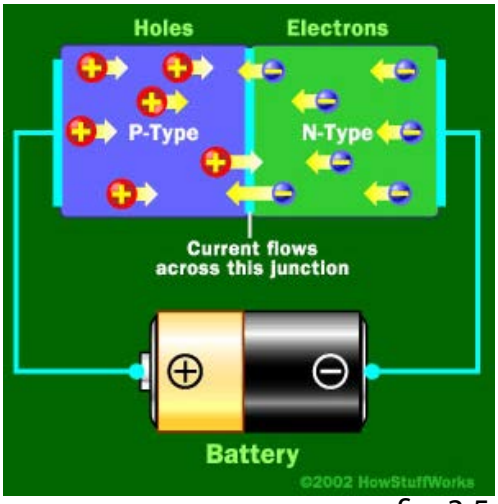


fig. 3.5

Light is a type of energy that is produced by an atom. It is made of small particle groups having energy and momentum but no mass.

These particles that are called 'photons', are the simplest and smallest units of the light. The LED emits photons, via the junction of the two atoms that are positive and negative.

3.5-3. The Usage Areas of LED Technology

LEDs are used in a variety of applications from TV remote devices to giant TV screens, from smart phones till wrist watches. Apart from these there are many different uses of LEDs in areas such as gardening, advertising, traffic applications, computers, cameras and many others. In this part, the sectors that the LEDs are used will be categorized and explained.

Indicators and Signs

Indication means to 'point something out'. So it has to be small, attractive but not very luminous.

The small size of LED bulbs makes them very suitable for many indicating applications. One color LEDs are very suitable for traffic lights and machinery signals. The battery indicators of many products need to be very small and may have to be in different colors depending on the application. The LED works in RGB color scheme and suitable color matches are beneficial for product signals.

The LEDs used for indication are usually the types giving diffuse and soft light. The soft light is good to not disturb the eye while attracting the attention of people. The softness of the light is mostly about the size and the brightness of the bulb. By reducing the brightness of an LED it is possible to obtain a soft and diffuse light, and by reduced brightness the look of the LED from different angles will be pretty much the same. An LED with high brightness and intensity would be very harsh from the top look, while from the side the light would be less bright and sharper.

Red, blue, green and yellow are the most preferred colors for indicators. White light has a disturbing effect when watched for a while. Plus, it can be perceived differently by different people's eyes. However the 'yellow' light is the easiest light color to see for human eye. Red light helps to keep right vision, puts less strain on the eyes and stills let the people to see properly. It has an effect of not impacting the vision in the dark. The blue color light has a similar value and position in the wavelength schema and it can be easily distinguished from red light. It stills to not disturb the eye but can be seen easily in the dark. The green color has a similar spectrum with yellow, so it can be seen very easily while it has a calming effect on people. It contrasts well with red light being the opposite code of red, without being too harsh or distracting for the eye.

So, the LEDs become very suitable for indicators because of their small sizes, possibility of different color coding and their low need of energy and long life span. They are very easily to install, program and maintain, making them a good choice for electronics and machinery applications.

fig. 3.6: The LED indicators are very useful and used frequently in different fields of industrial design.

Automotive

Nowadays, it is possible to find more than 300 LEDs in a car. Automotive applications of LEDs vary from intelligent adaptive headlights to turn signals and brake lighting. The use of LEDs offers a superior comfort and functionality to the drivers.

In rear lamps the red and yellow LEDs are used since many years. But the use of LED increased a lot in recent applications. For headlamps, especially the use of white color LEDs became very important and common to provide better lighting conditions for drivers. The white light is also used for signals and daytime running lights.

For rear lights many companies use 'Linear LED Drivers' while for front lights it's common to use 'High-current LED Drivers'. The use of LED for daytime running lights offers a big amount of energy saving.

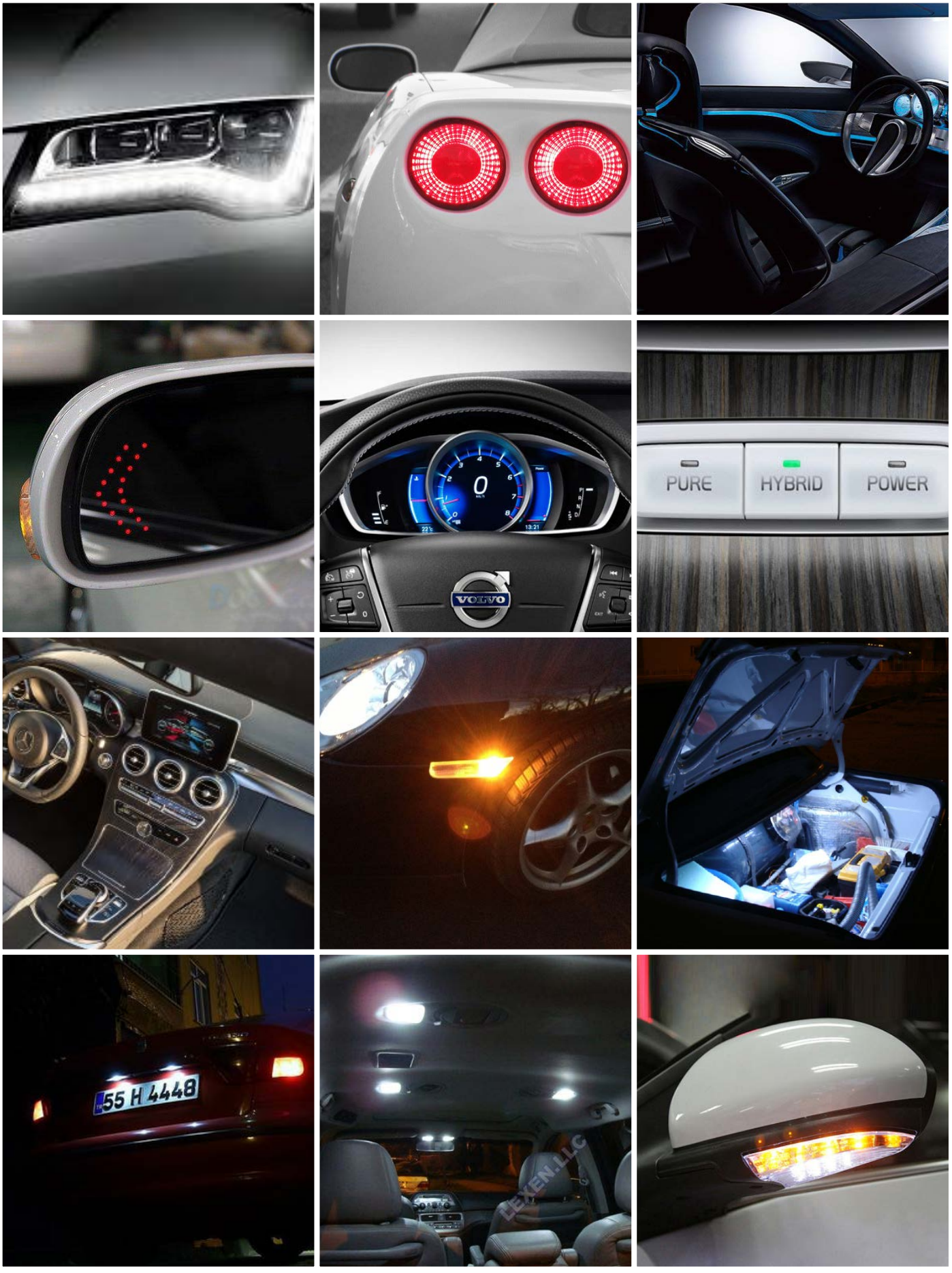
For the automotive design to achieve the right temperature of white light for the related application is very important. LED technology allows adjusting the color temperature itself, while it can be combined with other light sources to create different effects with lower costs. The greatest advantage of LEDs in automotive sector is the possibility to obtain 6000 Kelvin which is equal to the color temperature of the daylight. This offers a comfortable drive during the night time by providing a natural light color to be perceived as daylight.

In addition, the long life span of LEDs diminishes the breakdowns and eliminates the need of changing the bulb often.

Today, ambient lighting becomes a fashion state, while it has also a psychological side for the drivers. While a gentle and soft ambient lighting can make the interior of the car more attractive, it can even affect the safety of the driver. Many interior lighting designs reflect a light on the surfaces of the interior when the driver is going in or out or during the drive, to indicate some external risks. It also helps to change the mood of the driver, provides alertness and comfort.

The future studies and applications may include the effect of the lighting color for drive quality and enhance interaction of some functions such as navigation.

The effects of lighting are real and they can be precisely specified thanks to LED technology. The interactions such as adjusting the back and front lights automatically or indications for the driver depending on the exterior factors will be possible in the future thanks to the use of LEDs and sensors' combinations.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Displays/Screens

An LED screen is a video displays that uses light emitting diodes as pixels. Their efficient brightness allows them to be used in outdoor applications, while in recent years they became very popular in consumer electronics.

The latest technology of televisions is based on the use of LED screens. The studies are based on increasing the resolution by using more LEDs in smaller units. The LED displays are able to create general illumination in addition to visual applications. The first LED flat panel TV display has been found in 1977.

There are many different types of LED displays. . They can be categorized and defined depending on the display type, matrix, digit or alpha size, alpha size, color, common pin value, packaging type and number of digit, alpha, matrix or bars. The most popular types of LED displays are 'light bar', 'seven segment' and 'dot matrix'.

The LED screens provide a good performance level in outdoor environments that the projection and other screens cannot reach. So, they are used mostly in outdoor advertising, external coatings of the buildings, service sector, theatric applications, indoor advertisements, company publicities, fashion shows, hospitals, stores, hotels, tourism environments, mobile advertising, fair stands, shopping malls, soccer fields, other sports activities and in many other fields.

Lighting

fig. 3.7

With the development of technology, the high-efficiency and high-power LEDs allowed to use them for lighting applications. To save energy and thanks to their ecological friendliness LED light bulbs are started to be replaced with incandescent lamps in most of applications.

The LED bulbs are used in street and architectural lighting. The robustness, energy efficiency and the ease of maintenance are the first reasons.

They are also used in aviation lighting. Airbus uses LED in 'Airbus A320 Enhanced' since 2007, while Boeing uses them in 787 model airplanes.

The LED light bulbs are now used in many houses. Most of the lighting fixtures become suitable with LEDs and their energy efficiency makes them to be sold. They are commonly used in all market areas; standard lighting, AV, schools, hospitals and many other commercial or domestic places have LED lighting.

They are small, cheap and consume a little amount of energy, so that they became so popular even for daily lighting. The advantages and disadvantages of LED lighting will be discussed in the next levels.

Sustainable Lighting

Energy efficiency is needed for sustainable architecture. For this reason a comparison between the CFL, LED and incandescent lamp can be helpful to understand the superiority of LED in terms of eco-friendliness.

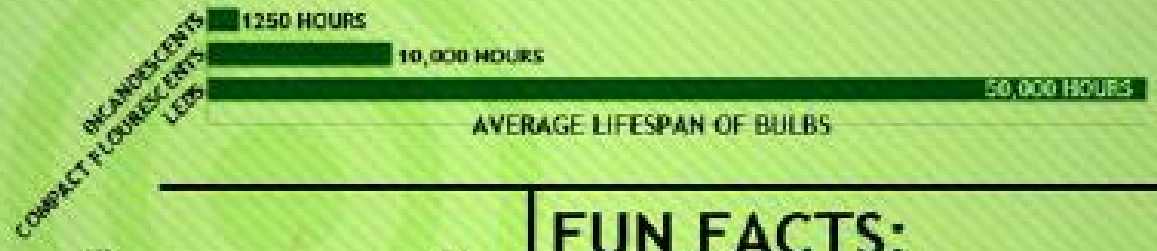
The life span is very important. As studied in previous chapters the longest lifespan is one of LED with 50.000 hours, while the life span of the incandescent is the lowest one. Compact Fluorescent lamps can stay alive a bit more than the incandescent lamps.

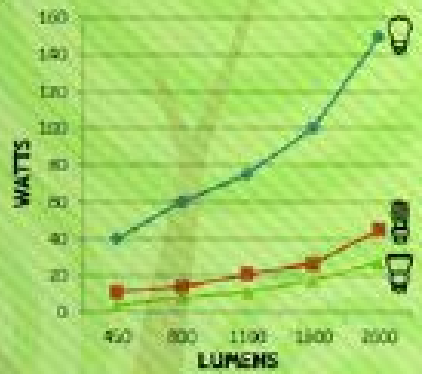
The watt of each bulb depends a lot. LED consumes approximately 10W, while this number is 14W for CFL and 60W for an incandescent light bulb.

So, the number of bulb needed for 50.000 hours of work is just one when an LED bulb is used. For the same case, it is needed to use 5 fluorescent lamps or 42 incandescent lamps for the job.

WHY LED?

	INCANDESCENT	COMPACT FLUORESCENT	LED
COST OF BULBS* 50,000 HOURS ELECTRICITY	$350 40 BULBS	$90 5 BULBS	$85 1 BULB
POWER CONSUMPTION	60 watts	15 watts	7 watts
CO_2 EMISSIONS PER YEAR	4500 lbs/yr	1051 lbs/yr	451 lbs/yr





LEDS REQUIRE FAR LESS POWER THAN INCANDESCENTS OR COMPACT FLUORESCENTS TO PRODUCE THE SAME AMOUNT OF LIGHT. PART OF THE REASON FOR THIS IS THAT MORE OF THE ENERGY USED BY LED BULBS IS CONVERTED LIGHT RATHER THAN EXPENDED AS HEAT. LEDS ARE EFFICIENT, ECONOMICAL, AND AN OBVIOUS CHOICE FOR REPLACING THAT NEXT PESKY BURNT OUT LIGHTBULB.

FUN FACTS:

-LEDS ARE SHOCK RESISTANT WHICH MEANS THEY'RE NOT PRONE TO BURNING OUT IF DROPPED OR BUMPED.

-LEDS ARE NOT TEMPERATURE SENSITIVE SO THEY WILL WORK IN HOT OR COLD CLIMATES WITHOUT FAIL.

-ON/OFF CYCLING HAS NO EFFECT ON THEIR LIFESPAN, SO FEEL FREE TO SWITCH THEM OFF AS OFTEN AS YOU LIKE.

NOT SO FUN FACTS:

-COMPACT FLUORESCENTS CONTAIN TOXIC MERCURY. NOT GOOD FOR YOU, NOT GOOD FOR THE ENVIRONMENT.

-INCANDESCENTS ARE BEING ALMOST COMPLETELY PHASED OUT BY 2014.

-COMPACT FLUORESCENTS ARE TEMPERATURE SENSITIVE WITH A RECOMMENDED OPERATING RANGE OF 10-120 °F.

-COMPACT FLOURESCENTS LIFESPAN IS DRASTICALLY EFFECTED BY ON/OFF CYCLING.

However the LED bulbs are more expensive than the two light types. A single LED bulb costs around 19$, while the CFL bulb costs 7$ and an incandescent light bulb costs 1.50$. But, for sustainability applications, the cost of a single bulb loses its importance. For 50.000 hours of use, the cost of an LED is equal to the cost of a single bulb which is 19$, while the total cost of CFL is 35$ and the total cost of an incandescent is 52.5$. Finally when the total cost for each type of lamp is calculated for 50.000 hours of work, the cost of LED is 69$, CFL's cost is 105$ and the cost of incandescent is 352$. These costs can be considered as proportional with the amount of saved energy.

Other Applications

There are a variety of applications that LEDs are beneficial as listed below:

- The remote control devices of the TVs or consumer electronics use the technology of infrared LEDs.

- The signal paths with electrical isolation that are created by LEDs are very useful for medical applications, especially for recording and monitoring devices.

- LEDs are used as motion sensors usually in entertainment applications, Nintendo Wii can be a good example for these devices.

- In 'pulse oximeters' they are used to measure the oxygen saturation.

- The RGB LEDs are preferred for the applications that require a specific color balance.

- The LEDs can be used as photodiodes, which makes the register of a touch by finger or a stylus on a touch screen device.

- LED lighting can also be useful in gardening. The UV LEDs can be used to grow a plant faster or to remove virus and bacteria on the plants by sterilization.

Finally, the LEDs have a lot of usage areas and benefits in many applications thanks to their structure and technological features.

3.5-4. Advantages and Disadvantages of Using LEDs

The LEDs can be the most impact technological development of our times. It has a lot of benefits and advantages that makes the life easier and more interesting, while it has also some negative sides and disadvantages in use. In this part, all the advantages and disadvantages of replacing the traditional lighting sources with LED will be analyzed.

3.5-4.1. Advantages of LED Technology

1. **Energy Efficiency:** LED is the most efficient lighting source with an estimated energy efficiency of 80-90% comparing with the conventional light bulbs. The efficiency of an LED light bulb is not affected by the shape and size of the shell, oppositely to the fluorescent and incandescent lamps.

2. **Long Life:** the LEDs and LED bulbs can be used up to 100.00 hours while their average life span is about 50.000 hours which is 5 times of fluorescent and 42 times of an incandescent lamp's life span.

3. **Impact resistance:** Thanks to the polymer shell of LED, they are difficult to damage or break, while the glass shield of an incandescent or a fluorescent lamp can be destroyed easily.

4. **Eco-friendliness:** As explained in the previous section, LEDs are poor in toxic ingredients. Also because their life span is very long comparing to the others, it has a minimum pollution effect for the world.

5. **Design Flexibility:** LEDs can be produced in any shapes and sizes depending on choice of the designer, they can be dimmed and their color can be set and changed to create different moods.

6. **Warm-up Time:** As they are not based on the use of a filament they don't have a warm-up time. An LED can reach the full intensity of light in microseconds.

7. **Dimming:** LEDs and LED bulbs allow adjusting the intensity of light by dimmers.

8. **Resistance to cycling:** LEDs are excellent for frequent on/off cycling. This is thanks to the very short warm-up duration.

9. **Low voltage:** A low voltage current is enough to activate and keep lightened an LED. This makes the outdoor lighting solutions, wider, easier and cheaper.

10. **No UV Emission:** LED illumination creates a little amount of infrared and almost no UV radiation. This makes the use of LEDs possible for UV sensitive applications such as lighting of museums, archeological sites and museums and for art galleries.

11. **Operability in Cold Temperatures:** LEDs are very suitable for very cold and low outdoor temperatures. The temperature may affect the performance of a fluorescent lamp, but LED can work in very cold environments.

12. Focus & Dispersed Lighting: LEDs are able to create focus and diffuse light depending on the application. LEDs are designed to focus light towards a specific location without the need of an external module such as a reflector. However, with a good design and placement, a nice smooth lighting mood can be created too.

13. Slow Failure: LED bulbs generally fail over time, by dimming slowly off. Instant shut-downs are not seen very often.

14. Long Term Cost: The long life of an LED provides less need of changing the bulb. As the price of a single bulb is more than the others, the total cost in time is much lower than an incandescent or a fluorescent lamp, as explained in the previous section.

15. Silence: The LED bulbs do not create noise oppositely to the fluorescent bulbs.

16. Safety: LEDs do not produce heat. So, the risk of an accident during the service is minimal, oppositely to the incandescent light bulbs.

17. Healthy Ingredients: LED bulbs don't contain mercury and toxic materials inside, which increases the healthiness of them, oppositely to the fluorescent lamps which contain a big amount of mercury.

3.4-4.2. Disadvantages of LED Technology

1. **Short Term Cost:** The price of a single LED light bulb is much higher than a CFL or incandescent.

2. **Dependence on Temperature:** The performance of an LED depends mostly on the environmental temperature. The performance of an LED decreases in hot environments.

3. **Area Lighting:** LEDs are the light sources that mainly create point light. To obtain an ambient light, it's needed to combine numerous LEDs in a single bulb or source.

4. **Variation of CCT (Color Correlation Temperature):** The tone of white color LED may vary from one to the other. When two white LEDs are placed together, it would be observed that they don't emit exactly the same color temperature.

5. **Fitting Problem of LED bulbs:** Most of the LED bulbs don't fit in the screw socket created for conventional bulbs. The socket has to be changed to a GU10 socket in order to replace the conventional bulb with an LED.

6. **Weight:** The LED bulbs are much heavier than incandescent and CFL bulbs. This may affect the lighting fixture design decisions.

7. **Effect of the Electrical Current:** The efficiency of an LED decreases by the increase of the electrical current.

8. **Blue Hazard Effect:** The blue and cold white LEDs can create a damaging effect on the eye that is called 'blue hazard'.

9. **Insects:** The LED light is more attractive for some kinds of insects. So, the use of LED bulbs too much can cause a problem of insects.

10. **Electrical Polarity:** LEDs work only with the right electrical polarity, unlike the incandescent lamps.

CHAPTER 4:
LIGHTING DESIGN AND TRENDS

Determination of the aspects constraining the lighting design, a compilation of lighting trends in 2016 and the benchmark anaysis

4.1- Lighting Design Constraints

To design a lighting fixture, the designer first needs a practical planning. This plan should include the decisions regarding the lamps and fixtures to be used, the arrangement and installation of these fixtures, their control gear and the other control equipments. The priority of the lighting deign is to increase the quality by considering to balance the luminance and the cost.

4.1-1. Lamp Selection

The choice of the light source has a decisive role on the quality and final effect of the lighting design. Not only the quality of lighting, but also the entire cost of the designed lamp is mainly related to the choice of the light type. All the equipment that will be used in the final product will be implemented according to the chosen light bulb. So the first step and the most important step is the lamp selection.

The choice of luminous color defines the atmosphere that will be created by the new design. At this point the color rendering, brilliance and modeling are related with the light type and the bulb. Actually it's not directly the lamp chosen which creates the effect, but the result comes out by the combination of the lamp, lighting fixture and the enlightened environment.

The consideration of the environment is very important. The modeling and the brilliance can be used for advantage as they may become a problem because of a wrong design. The modeling contains the planning of the light and shadow areas created in the room by the lighting element. The brilliance consists on the reflection of the light emitted by the lamp on glossy
objects in the environment. Both of these aspects are important features that have to be considered when designing a new lighting element.

The color rendering is another issue that is directly related to the lamp choice. The light source can have a good color rendering only if the deviations between color ranges are very slight. The color rendering quality of a light source depends on the specific composition of the lamp spectrum. For optimum color rendering quality, a continuous spectrum is needed. The spectral distribution of the light is also a factor affecting the color rendering quality.

The luminous color and the color temperature of the light emitted are also related to the spectral distribution of the light, similar to the color rendering. In case of the incandescent lamps this distribution is a result of the temperature of the filament, while in case of the discharge lamp a comparative value is needed as a guideline. The color temperature is usually used as this comparative value. The luminous color is basically categorized in three; the warm white, the neutral white and the daylight white are the color temperature categories of the light. Departing from this, in case of the discharge lamp, it is possible to create various combinations of colors and effects.

The efficiency of lighting fixtures and installations depends largely on the lamp choice. The other factors such as the selection of the control gear and control equipment are less important for efficiency. Plus, there are many criteria to be considered when choosing a lamp for high efficiency. These criteria can be listed as:

1. The luminous efficacy of the lamp
2. The rated lamp life span
3. Lamp costs
4. Range of power capacity

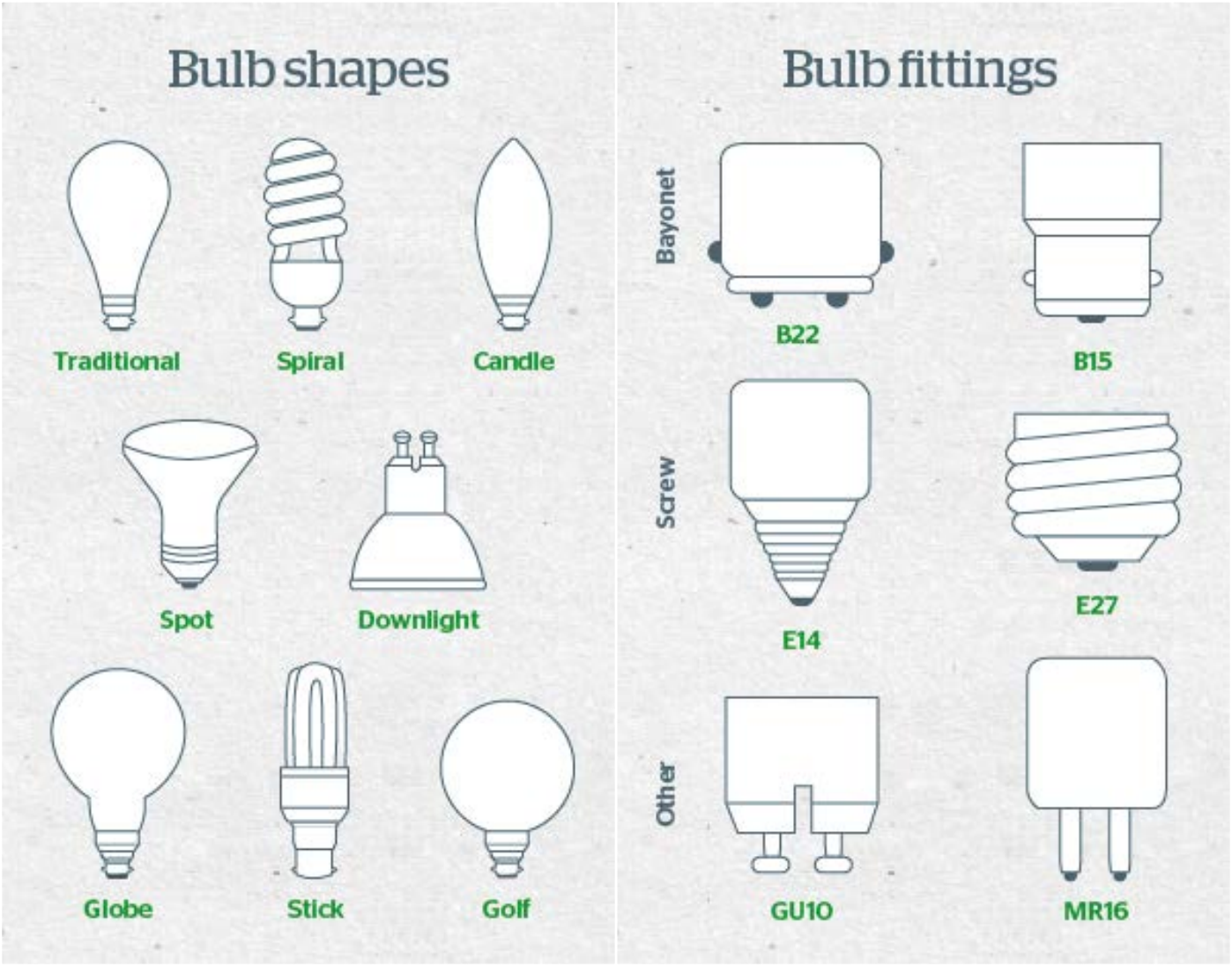


fig. 4.1

The dimming quality of the light sources is important, especially in the spaces with changing activities and circulations, when different atmospheres are desired or required. The dimming option can also be used to adjust the light intensity according to the natural lighting depending on the day and night time, for example. The incandescent lamps and the halogen lamps are the types that are very suitable and easy to dim. The fluorescent lamps are more difficult and expensive, but it is also possible to integrate dimmer control. From the technical point of view, the discharge lamps should not be dimmed. LED technology allows setting the brightness very easily, and dimming is an important tool for brightness control.

4.1-2. Fixture (Luminaire) Selection

The choice of the lamp is related with the technical quality of the lighting design. However the total effect of the lighting requires a good decision of the fixture design as well. The choice of the lamp and the fixture are therefore closely related, while the lamp is placed into the fixture and the fixture completes the effect of the lamp. The choice of the lamp may limit the design of the fixture, while the choice of the fixture may require some limitations on the lamp choice.

Standard fixtures vs. Custom Design

In most cases the standard fixtures answer to the need of the customers. Especially the fixtures that are sold with their compatible lamps are the easiest way and this solves the problem to find the right match. However, in case of very large and prestigious spaces or very small places, or in case of missing sunlight, the design of the specific lamp becomes important. This allows the arrangement of aesthetics in interior design and architecture, and the specific character of the new fixture may change the total success of the project. However the additional costs for development and the additional time to be spent have to be calculated and added to the total costs of the whole project.

Integral vs. Additive Lighting Solutions

In the architectural design, the implementation of lighting can be realized in to ways. The first one is to integrate the lighting solution directly into the architecture, and the other one is to enhance the architecture with additional lighting fixtures. The first option offers the possibility of an 'invisible' lighting while in the other case the lighting element is visible and even may become the center of interest in the space. The choice is about the desires and decisions of the interior and industrial designers, but at the end, the choice of the lighting fixture is an important factor to define the character of the interior.

Stationary vs. Mobile Lighting

This decision is about the needs of the environment rather than the design choices. In some spaces the lighting may have to be flexible and adaptive to many situations. There are some key ways to provide the flexibility. The changes can be related to time or other special aspects, while all these are provided by the use of a "lighting control system". Single fixtures or fixture groups can be turned on/off or dimmed depending on timing, sunlight contact or the use. The upper level of flexibility is movable fixtures such as directed spotlights that change angle and direction depending on the special adjustments or programming. The highest level of flexibility which is mostly required for exhibitions is to use tracks or trunking systems to slide the movable spotlights. By this way, the light can be translated in two axes and can be rotated according to the application.

Wall Lighting

Wall lighting may answer to several needs. First of all it can be used to highlight some informative features such as wall maps, texts, charts or objects such as paintings, posters or retail goods, architectural features etc. the wall lighting may also serve to show the wall up as a room surface itself and finally to create general, soft ambient light.

To highlight certain areas of the wall, the spotlights and recessed directional spotlights are the most suitable types. This choice depends on the desired flexibility. In case of glossy surfaces such as paintings behind the glass, the importance of the lighting angle increases a lot. The light that is parallel to the floor is mostly suitable to accentuate the architectural features of the wall. Totally uniform wall lighting can be obtained by wallwashers or washlights.

To obtain an ambient lighting, the wall fixture has to be planned to emit horizontal light for a soft general lighting.

Ceiling Lighting

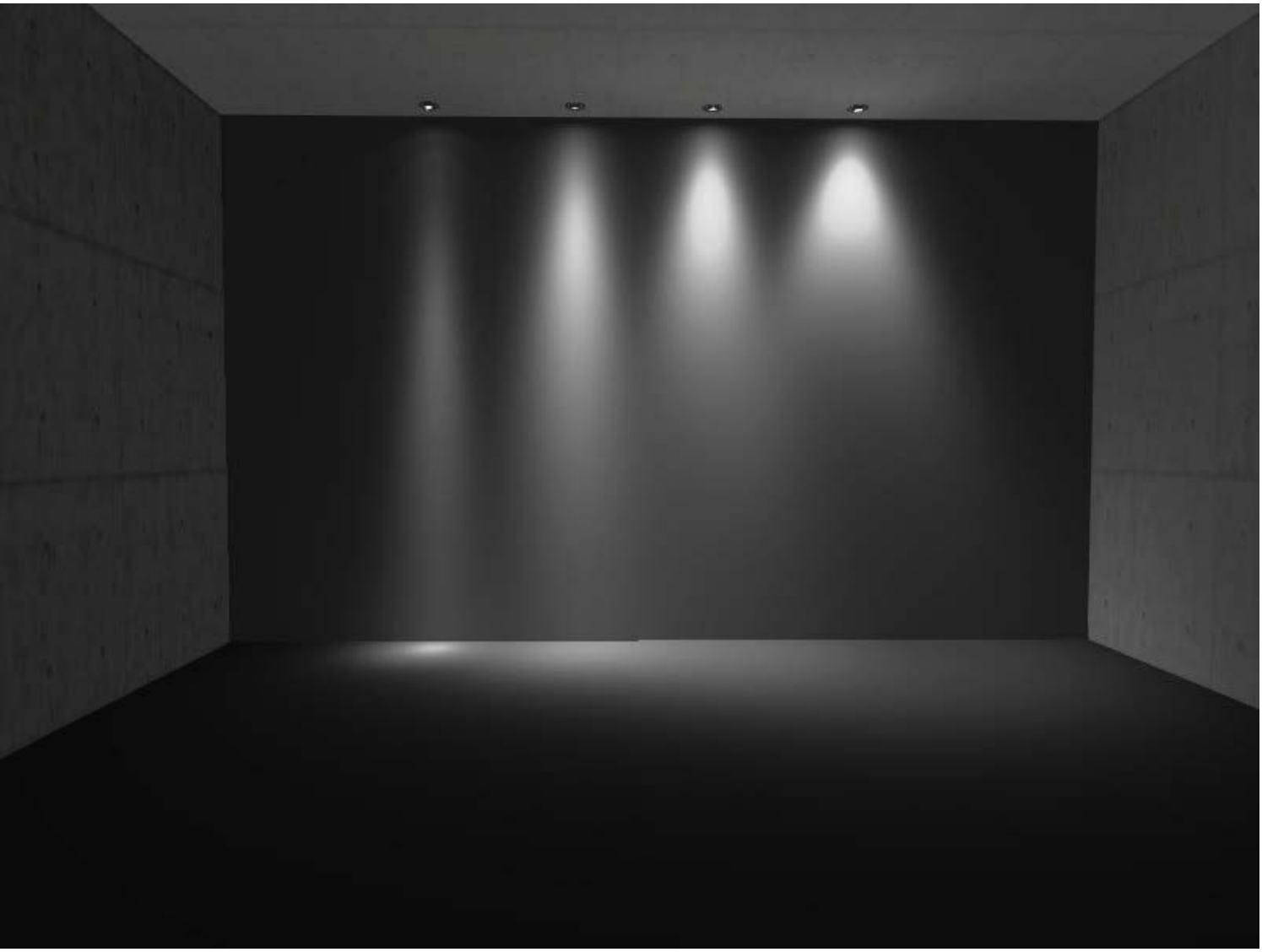
The most common type of lighting is realized by ceiling fixtures. They are suitable for a variety of applications and spaces such as domestic use, office use, retails etc. ceiling lighting is usually used to create an indirect general lighting. In this case the fixture becomes the brightest surface of the room and this may become disturbing and tiring for the eye after a while. A particular relevant type of ceiling lighting is the cove lighting. This is the case of a standing special ceiling used when the walls are not available for mounting the fixture. Another way to soften the effect of the light fixture is to lighten the ceiling at the upper half by a pendant of a light structure. This would help the light to be more diffused and to reduce the effect of glare on the eye.

Limiting the Luminance

The way to balance the glares depends on the type of the lamp, if it is stationary or movable. In case of stationary fixtures, it is more possible to avoid both the direct glares and the reflected glares. The level of elimination of the direct glare depends on the light distribution of the fixture. There are some standards for dimensioning the enlightened area by the fixture, but basically the method is to increase the cut-off angle as much as needed. In case of reflected glares it is not totally possible to avoid, but the reflection angle can be set between 30 and 40 degrees to minimize sharp reflections.

Safety Requirements

All lighting fixtures have to meet the safety requirements. In some countries there are provision laws to guarantee the safety of the fixtures. In other cases some common requirements are considered as a guide. The fire safety is the first aspect. Depending on the fixture and the lamp selection, the lighting element may have to be avoided to be near the flammable objects and furniture. The atmosphere where the lamp will be placed is also important; the fixture doesn't have to be placed in a space containing flammable gases. The lamps that are planned to be mounted have to be approved by restrictions.



The selection of the luminaire affects the created lighting effect substantially.

Accessories

There are many available accessories for the light fixtures to change the effects, avoid glares and enhancing the mechanical properties. This includes filters to change the color rendering, UV emission or infrared radiation, lenses to change the distribution of the light (to focus or diffuse the light), or accessories regarding to the protection aspects. There are many other applications based on the use of external accessories.

Lighting Control

The lighting control systems are preferred to be used for creating different theatrical effects. These applications mostly concern to the architectural lighting. Some of these effects can be obtained by conventional lighting elements through additional accessories mentioned before. If a high level of flexibility is requires, the use of special fixtures and equipments are required to create effects that are related to time and location.

4.1-3. Layout

Depending on the project there may be a variety of conditions to define the lighting layout. A uniform lighting would require a regular way of placement of the fixtures in the environments. Different needs of the area with the objects or parts placed into different regions of the area may require a specific layout. In such cases, the fixtures have to be placed according to the parts of the room that have to be highlighted.

The layout can be affected by the fixture type and even by the shape and size of a ceiling lamp, for the structure that have to be considered when creating a new lighting layout. The air conditioning and the acoustics may be critical features for which the designer has to work coordinated with the engineers.

As the technical and functional aspects influence the lighting layout a lot, they are not the only features that have to be considered. The aesthetics of the ceiling design is an important feature influencing the total effect of lightened environment. For example, a ceiling that creates a uniform grid of lighting would help to create a uniform and smooth lighting in the environment. On the other hand, a separated, heterogenic lighting can be created by the use of fixtures that create different lighting grids, placed uniformly in the environment.

However, the lighting layout and the lighting effect are not directly related to each other, while the designed layout can be obtained by a variety of fixture design solutions and vice-versa; with a specific fixture design, a variety of effects can be created by different lighting layouts.

fig. 4.2

The two pictures above are showing the two different lighting layout solutions by the use of the same light source that is CFL (Compact Fluorescent Lamp). In the first image, the lamps are placed as ceiling lamps and they are directly lightening the top surfaces of the desks. The lighting is uniform and the light reflected on the desks is sharp and bright. When looking on the details, it would be observed that there are no reflections of light on the window. This type of layout is ideal for 'work', mainly for uses that need 'uniform and focused' lighting such as drawing.

In the second image on the left, the fluorescent lamps are used as wall fixtures and this provides a more diffuse and general lighting for the room. However, in this case, the desks are not lightened well and there are some shadows areas on the work surfaces. Additionally, the general effect of room is darker and there is a sharp reflection of the light source on the window. It's obvious that this type of lighting is not convenient for this room and the visualized application. To see the effect of 'lighting layout' more clearly, the schematic views are shown below.

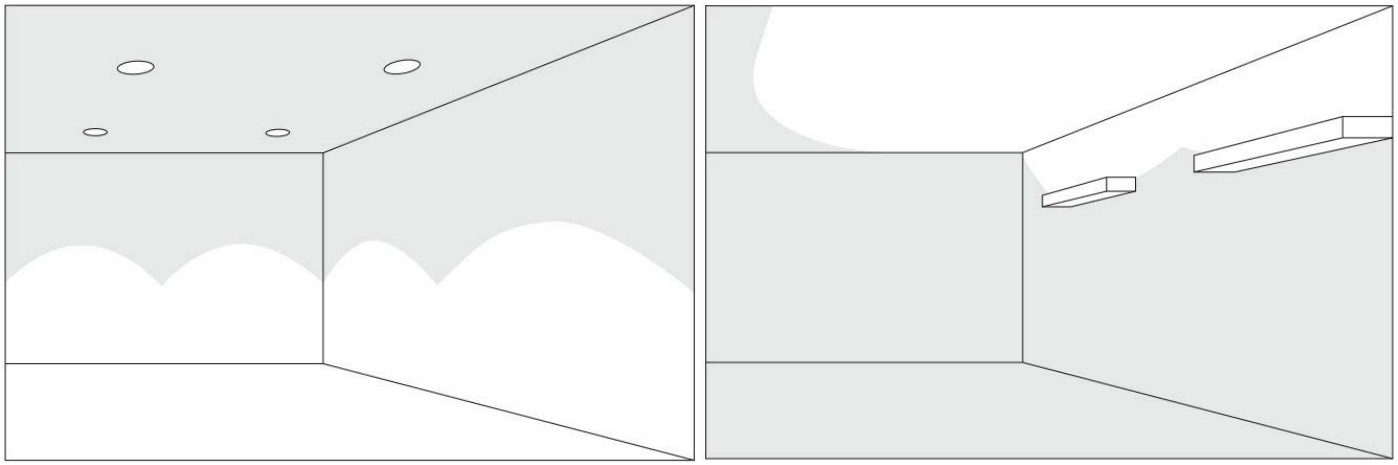


fig. 4.3

4.1-4. Switching and Control

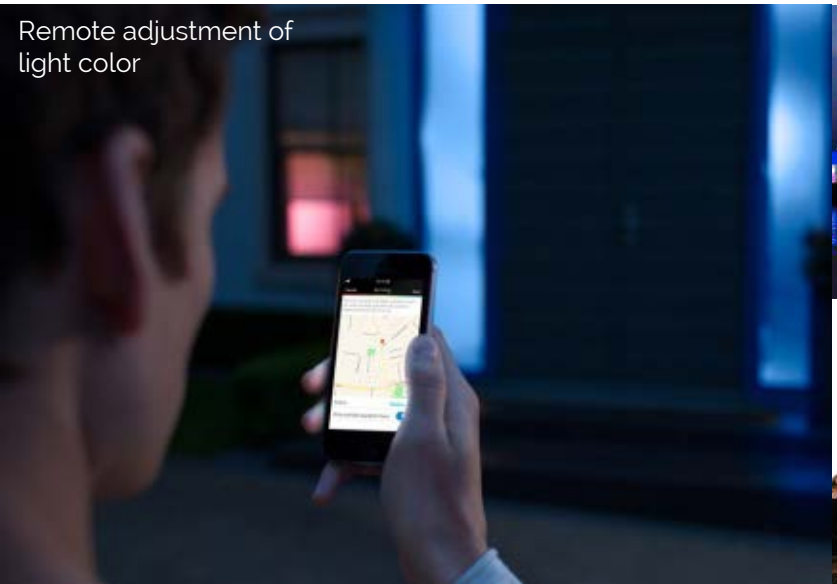
The simplest way of controlling a lighting system or fixture is 'switching'. (See 2.3-1 for more detailed information). This method offers only two states of light; on and off modes. A good lighting design may have to provide various opportunities for arranging the state of the light.

Even if a space needs a single type of lighting, the states of daylight and other external Factors are affecting the lighting of the environment. A good design has to be able to maintain the state of the room well, by keeping the light level linear. Changing environmental conditions and different uses may need temporal adjustments. For this, there are many methods that may be used and profited. Dimming and switching are the first methods to be used for adaptation (see 3.4 for dimming and other lighting control systems).

Dimming is a very useful for the synchronized adjustments depending on the daylight. The lighting can be dimmed up and down according to the amount of daylight perceived in the room. Another way to make immediate changes in lighting is to create groups of lighting fixtures in the room, to adjust them separately depending on the need. In this way, a part of the room that doesn't meet with the daylight a lot can be enlightened more by that specific group of luminaries while at the same time another part's fixtures are switched off or dimmed down because of high level of sunlight. These methods increase energy-saving and also the efficiency of lighting
for the specific application.

The switching or dimming of these groups of luminaries can be provided manually by a control panel or a remote, while it can be made automatically by programming or more efficiently by sensors. If the number of fixture is high or the area is very large, it is usually recommended to use an electronic control system. These systems provide precision in creating specific light scenes.

The recent developments in control systems' technology allow creating also theatrical effects in architectural design. Besides the control of intensity, the luminous color of the light, the spread of the light beams and the direction of the light are adjusted easily.


Remote adjustment of light color


Remote color setting for architectural structures


Lighting control of big buildings

4.1-5. Installation of the Fixtures

There are many types of fixtures that are designed and they have to be installed in the space correctly, in order to get the highest level of efficiency. The location of the fixture affects the luminous effect and intensity of perceived light.

A ceiling mounted just on the top of a desk can provide a high functionality, while it can cause an uncomfortable use because of its height or intensity. A fixture placed near the window can waste energy, while it can provide benefit with a well-directed focused light.

For ceilings, the installation mostly depends on the ceiling type. The material and size of the ceiling affects the installation a lot, while the mounting surface has a big importance as well. A wall fixture may be mounted onto or into the wall; again this depends on the wall material and the fixture size, as well as the target use.

Mounting of the lamp affects the intensity, diffuseness and the direction of the light which are the three main aspects composing the total effect of lighting design.

4.1-6. Lighting Costs

The cost is an important aspect to be considered and calculated when designing the lighting of especially large areas. It is necessary to consider the fixed and variable costs in total. The fixed costs do not contain the operating costs. It is only the total amount of the fixture costs, installation and cleaning/maintenance costs. The operating costs depend on the time and are comprised by the variable costs of lighting.

The variable cost includes also the cost of energy, material and even the salaries of the staff working for production, transportation and installation. The cost of installation can be estimated by some standardization.

For example, in 2016, a 18 inches diameter with 6 inches thickness drum style lamp with chrome, brass or nickel finish options, that has four bulbs with 60W and 120V has a cost between 50-120$. The labor of installation lasting about two hours costs 155-190$. The materials and supplies cost about 20-25$ and so, the average cost per fixture is 225.5$.

Finally, the costs are one of the most important factors for customers, so that the designers and producers have to take it in consideration.

4.1-7. Maintenance

The maintenance of lighting is based on the replacement of the light bulbs, cleaning of the fixtures and re-adjustment or re-alignment of spots or movable fixtures. The main aim of maintenance is to ensure that the lighting installation realizes its efficiency properly. It aims to avoid any possible malfunctioning or reduction of the luminous flux. The luminous flux can be decreased mainly because of the defected lamps. But besides the quantitative factors, there are also many qualitative issues that may require maintenance.

When a single bulb fails into a large lighting system, the total effect may change according to this small failure. A missing beam of light in a wall lighting installation for example, would be disturbing for the eye and reduce the quality of the design. In such cases, the defected lamp has to be changed as soon as possible, without waiting the regular period of maintenance, especially in specific uses for which the lighting quality is important.

The adjustment of fixtures is also considered within the qualitative maintenance processes. In this field, the fixtures may have to be aligned frequently, especially in retail applications, because of the changes in the decoration such as the shelves, stands or showcases. These changes of alignment are important to precisely highlight the desired good/product and to achieve a proper and homogenic lighting that doesn't disturb the customers' eyes.

The role of the lighting designer in this case is to create a maintenance plan that meets the needs of the target use and environment and to provide the detailed information for the maintenance features. This plan and information have to support the operator to maintain the installation within regular periods, to check the technical requirements, if they are met and the lighting is performed as planned or not.

4.2. Lighting Design Trends 2016

This part is a mix of several resources about the lighting design trends and the observations about the use of these trends in architectural lighting application.

Trend 1: Use of White Color

The white color symbolizes the pureness and brightness. The white color match with lighting fixtures fits with a lot styles of interior design, such as an urban loft, a small cottage, a modern apartment or a classically decorated small house. A good design coated with white color would brighten up the darkness of the room, add a pure touch and value to the decoration. A full white space can refer to a vintage or modern style. White color has a neutral character that makes it suitable for a variety of combinations. A white pendant or wall lamp would match with any spaces and add a pure elegance to the environment. In 2016, white lamps will be seen often.

Trend 2: Sculptural Fixtures

In 2016, the main of the lighting design is to create a focal point in the house by the attraction of the lamp design. So, the lamp designs will be based on looks creating sculptural effects that will be the most significant object in a room.

These lamps are great to change the atmosphere of the space; they will catch an entire look with the furniture and create an ambient light for a sophisticated environment. The customers desiring to have sculptures but who don't have enough space may freely choose a pendant lamp like this, to achieve the desired style.

Trend 3: Combining Materials

The combination of two opposite materials such as black iron and crystal glass creates innovative designs in every field. The mixture of metals, crystals, colors and different finishes helps to add glamour in the interior design, this year. As matching colors makes the decorative combinations easier and richer, the combined materials will help to fit the lighting fixture with various decorations. On the image, a ceiling lamp made of steel and glass is visualized. As seen, the circular shapes of the crystal modules are sharpened and contoured by steel frames. The refraction of the light by crystals is balanced by the use of steel material. This trend will be helpful for designers to create balanced geometries, as well as the customers to find the right matching lighting fixture for their house.

Trend 4: Solid Glass with Color

Lamps made of solid glass material have a modern eye for customers. The material itself is soft and neutral and the color infusion in glass accentuates the fixture. The transparency balanced by color allows the light to diffuse in the environment, without being very sharp. The use of smooth surfaces creates nice reflections in the room, while it can be enhanced with refractions by adding bump textures on the glass material. The colored glass is soft and elegant; it can be designed colored to be harmonious with any decoration.

Glass can be matched with traditionally decorated spaces as it is also a traditional material, but new designs may consist on different shaping of glass to create very modern atmospheres.

Trend 5: Geometric Forms

3D printing made a big influence on interior design and product design. It makes any shape with edges or lattice structures possible to produce. This year, the parametric design brings the geometric inspired interior elements with it, and lighting fixtures are one of the examples. The optical illusion of these fixtures is fascinating and 3D printing offers a big ease of production. By this trend, it is possible to create very different characters for product designers and customers, to make difference in design and decoration.

Trend 6: Mid-century Modern

A big design trend in 2016 is 'Mid-Century Modern' referring to the designs of especially Kichler, Sonneman, Progress Lighting and Hinkley. This trend consists on the looks of 50s and 60s. The 'Less is more' attitude is implied in the lighting fixtures, expressing a desire for simpler times. Light tones, woods and white color are very common in Mid-Century Modern designs. These designs play well with decoration, while their light and soft colors blend well easily with decors from modern to more traditional.

Trend 7: Oversized Fixtures

The oversized fixtures are another big trend in 2016 including chandeliers, pendants and ceiling fans. The idea is to create a big focus point by using huge ceilings in the rooms even if the space is very small. The effect of big ceilings in small rooms increases the attraction of the interior design. They are perfect to pull the attention on a specific point in the room. They help to fill the space and direct the eyes' attention upwards. The big ceilings create softer and diffuse lighting effects in the interior design.

Trend 8: Natural Light

A modern fixture that equally distributes the light in the environment is one of the lighting trends in 2016. In this concept, the light sources are generally hidden in decorative features to emit a soft natural light. The LED strip is one of the most popular light sources becuse its high brightness and diffusible light allows creating very soft lighting environments and it is energy saving that means to reduce the electrical consumption and costs. So it can be declared that this concept's main tool is LED technology. This type of lighting is ideal for bedrooms, living rooms and many other spaces that may carry a soft light and which doesn't need a directional light for specific applications. The brightness of the room can be dimmed up and down to create different atmospheres in the room and these effects would be very soft and natural thanks to hidden light sources.

Trend 9: Soft and Smooth Lighting

This trend is similar to the previous one; the main difference is the lighting fixture. In this case the light is not hidden but has a fixture. This fixture has to be designed to lighten a big are by creating a soft and diffuse light. In this way the fixture is in contrast with light and creates shadow and light areas in the room to build the atmosphere. Differently from the previous concept, this lighting doesn't only enhance the architectural structure of the space, but it adds an additional value to the interior design. By this method, all the room is lightened equally; the shadows are soft and diffuse, while the lighting element is still in the center of attention.

The lighting fixture that is in the form of a 'panel' can be designed with different shapes allowing the designer to provide different shadowing.

Trend 10: Creating Artworks

Another trend of 2016 is to implement lighting in artworks, or vice-versa; the artworks are used also to brighten up the space. The lighting source is implemented in a sculpture or behind the paintings, so that the room is softly lightened and the artworks are highlighted to pull the attention. In an additional way, the artwork can be created by the light source itself, by using colors, textures and even animations. This method can be freely used for houses; especially in kitchens and living rooms, and also for retail applications, such as in a store or a café.This method articulates the artwork itself, while it doesn't help to enhance the architecture.

Trend 11: Decorative Accents

Adding decorative accents into the houses and office areas with garlands and unusual lighting elements is a popular way that makes funny and surprising touches in the environment. By using flower lamps like in the picture, will create happiness and brightness in the space, while they support the general lighting.

This method helps to change the atmosphere, enhance the lighting and to add a function to the decorative objects.

Trend 12: Good Illumination of Works Surfaces and Mirrors

This year, the lighting of mirrors is provided by integrated lighting sources. This helps to avoid the reflection of the light in the mirror and unequal distribution of the light beams which causes sharp and annoying shadows for the user. The light is usually dimmable to provide comfort for the eye. This lighting method looks more for bathrooms and bedrooms but it can be used also for living rooms; a big mirror with soft lighting would change the entire atmosphere. The illumination of the work surfaces such as the desks is also provided by similar methods; the implementation of a diffuse light source in the working environment avoids shadows and relaxes the eye.

Trend 13: Changing the Geometry of the Environment

The contemporary lighting ideas are great to change the illusion of the geometric features of the architecture, to add depth in the space and balance the proportions. This allows creating unusual interior designs while providing brightness and a modern effect in the environment. These lighting designs can be used to create the harmony with the interior, as well as it can be used to break the harmonious atmosphere. The illusion of light can show a space bigger, or hide an undesired feature of the architecture.

Trend 14: Combination of Modern and Traditional

The use of traditional lighting elements together with a modern lighting technique adds a soft touch to the area. This trend is generally speaking a combination of the sharp lines and edges of modern design trend, and the soft and curvy look of traditional lighting elements. As the fixture itself, is a feature to be considered, the light type and the source can also be combined. A combination of cold white light of LED used as a ceiling light with the warm toned yellowish white color of an incandescent used at a lower height would provide an efficient and softer light.

4.3. Benchmark Analysis

This part is including a bunch of light designs from 2016, mostly gathered from furniture fairs and exhibitions of this year. The mentioned products are chosen from a variety of designs to exemplify the design point of view of the year.

1. Examples from Salone del Mobile 2016, Milano

Four Lamp *by Philippe Tabet*

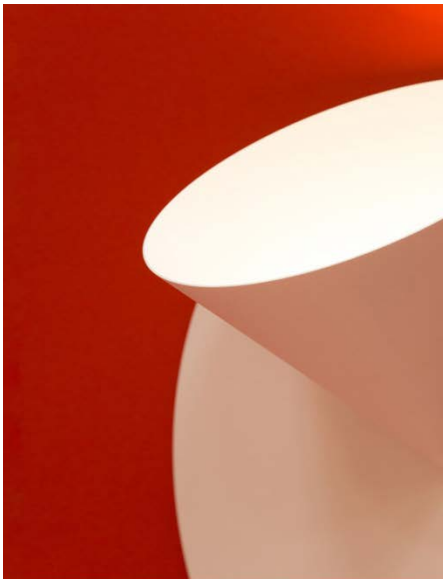
The designer gives the keyword of the design as 'versatility'. This white lamp series is following the design trend by using a pure white color. It combines two materials; plastic and steel in order to create a sharp contrast. The 'Four Lamp' can be used in three modalities: as a pendant, a standing lamp or as a table lamp.

Control Lamp *by TAF*

This lamp reflects a back to the past vision which corresponds to the trend n.6, the Mid-century Modern style. The lamp has a very basic shape that highlights the function of the object. The design aim is to combine the references to hi-fi and industrial machinery, with a dimmer to activate and adjust the light by using a simple knob reminding the volume control knobs. Everything is placed on a simple metal basis. The design is made for the Scandinavian brand *Muuto*.

Cirkell Wall Light *by Daphna Laurens*

As being an exercise of circles and balance, as declared by the designer, the metal wall light creates a sculptural look on the wall which creates a soft ambient lighting. The design fits with the trend n.5; based on the use of the geometric shapes.



Pod Light *by Simo Serpola*

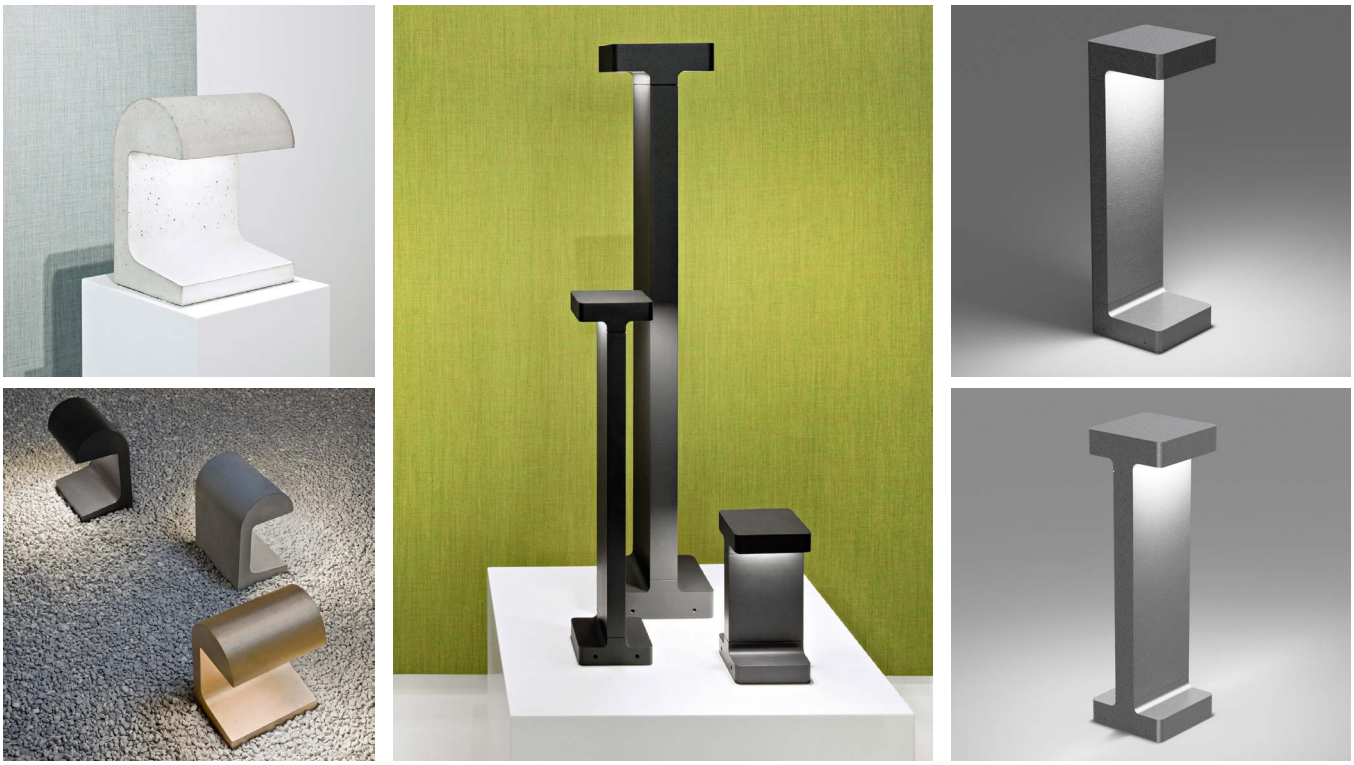
Another lighting highlight from Salone del Mobile was this foldable tripod lamp from Simon Serpola, the Finnish designer. The materials of this lamp are aluminum for the shell and oak for the structure. Not only by the used materials and the geometric shape of the design, but also with its 'vintage' look, the lamp is harmonious with the design trends of 2016.

Polar Desk Lamp *by Ross Gardam*

The Australian designer Ross Gardam has created a table lamp containing a rotating mirror allowing to adjust the direction of the light and shadows. The designer declares that he inspired from the states of the moon when creating the rotating circle. This circular panel is attached to the body magnetically and the design of the fastener allows the circle to pivot across the light source. The basis is made of ceramic and the upper disc has white, blue, pink and gold color options, all with reflective finishes. The white color of the main body and the mix of geometric forms are the trending features of the design.

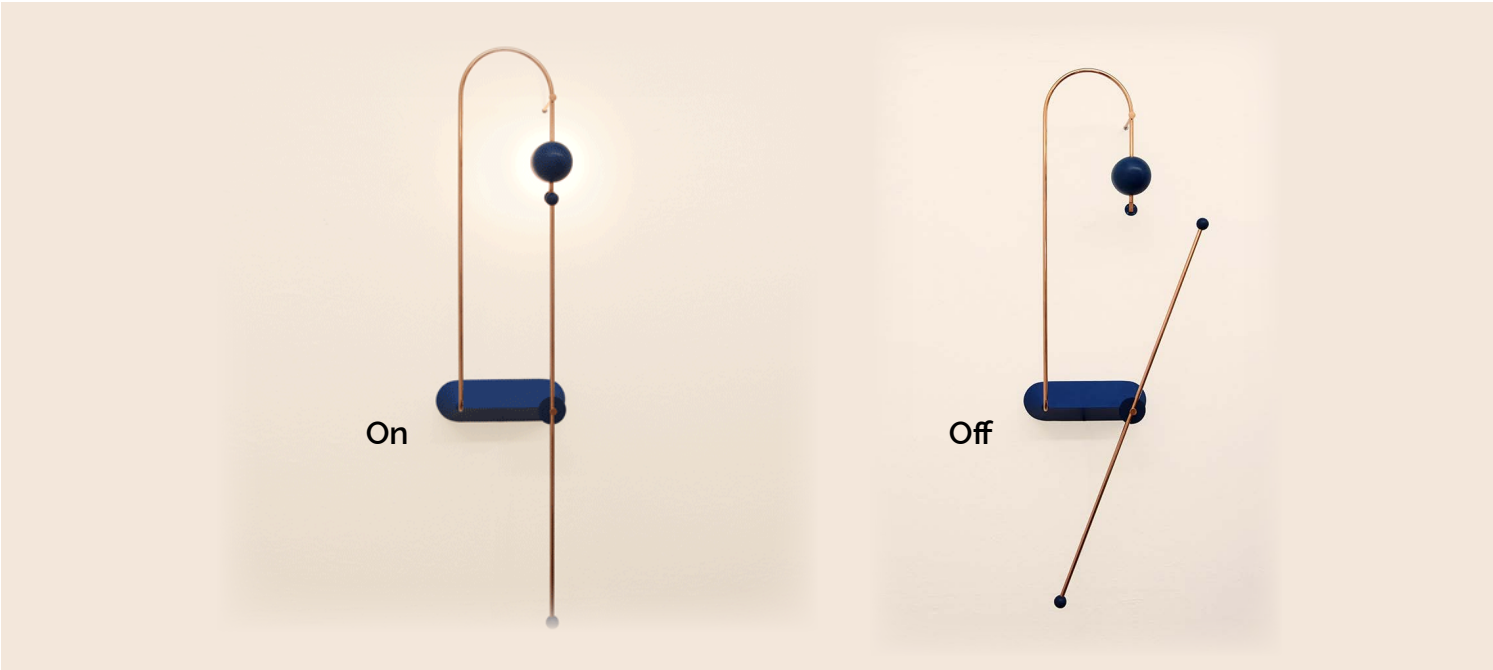
Cast-Concrete Lamp Series *by Vincent van Duysen*

The Belgian designer Vincent van Duysen has creates a new lamp series for the Italian brand Flos. This series contains C-shaped and I-shaped lamps made of cast iron or concrete materials; these lamps are both floor or table lamps and their forms remind the style of Le Corbusier. The lamps have different choices for finishing such as oxidized bronze, coated aluminum, cast iron or pure concrete. The geometric form is iconically suitable with the trend n. 5.



Node *by Odd Matter Studio*

The Amsterdam based studio wanted to create a lamp showing the making and breaking states of a circuit, so they have created a series of light turning the light on and off by making and breaking the connection of the two ends of the lamp. The rotating arms complete the loops of copper to switch the light and vice-versa. The lamp shades are made of a plaster and resin composite material Jesmonite. The materials and the colors reminding the old decades are a visualization of the 'Mid-century Modern' trend.



Optical *by Lee Broom*

The lamp is inspired from a graphic pattern, and is made of powder coated steel and opaque glass that is in the form of a sphere. The asymmetrical black stripes create a contrast with the perfect spherical form of the lampshade, while the trend of using geometric shapes is followed on the upper part of the lamp. The pattern changes depending on the angle and direction of vision. The lamp is released in Salone del Mobile 2016 and will be available for sale in September 2016.

2. Examples from Stockholm, 2016

Dalston Lamp *by Industrial Facilities*

The London design studio Industrial Facility has created the light design Dalston Lamp for the Swedish brand Wästberg. The lamp uses LED technology, for which the LED module is designed separable from the body in order to provide ease in installation and maintenance. According to this structure, the pendant can be lifted up easily and can be changed when desired. Glass and metal shells come in three different sizes and over 1000 colors available for the choice of the customer. Thanks to this opportunity, the lamp can be customized by the clients. The lamp has a form and finish reminding the Mid-Century Modern style.

Balancer Lamp *by Yuue Design*

The Balancer Lamp by Yuue Design has been released in Stockholm Design Week 2016. The lamp is composed of a spherical end that emits the light mounted on a long steel rod carried by the perpendicular pole. A circular knob is connected to the end of the upper rod with a curved lever. By sliding the knob up or down, the level is moved and the angle of the upper part can be adjusted by this rotation. The lamp has a cylindrical basis made of marble to provide the balance. The system and the designed form of the lamp are all respecting the pure geometry. The Balancer Lamp is produced in two colors: white and black.

Plane Lamp *by Front Design Studio*

The Plane Lamp designed by Frot Design Studio for Zero carries a simple geometrical form convenient with the 2016's trend, while combining the two different materials which are metal and glass; as being another trend of the year. The keywords of the design are 'sharpness' and 'weightlessness'. The designers declare that the point of inspiration was the material of the light source reminding an oversized lense and they wanted the function to be in the center. The lamp is available in red, yellow, black and chrome with glossy finishes.

Source Materials Collection *by MSDS Studio*

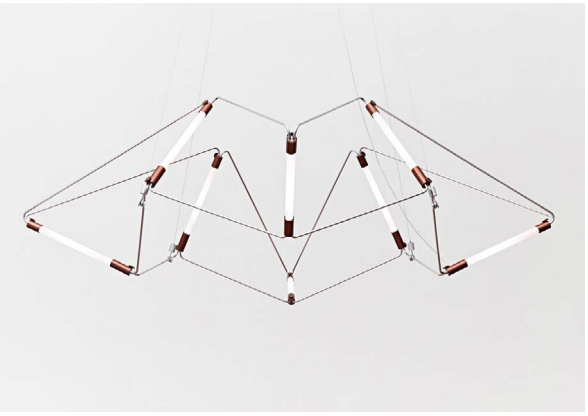
The Canadian Studio MSDS has released a light and furniture range which includes a chair, a table and two lamps that remind the 17th century. The pendant light of the collection is a minimal aluminum lamp composed of smaller shades which has a sand-cast finish with a textured surface. The other lamp which is actually a table lamp has a cylindrical basis holding the petal shaped top shell; that have been slip-cast in a single piece.

3. Examples from New York, 2016

Circuit 7 *by Apparatus*

The New York studio Aparatus has launched the new lighting designs for 2016. The Circuit 7 Lamp is made of a LED tube nestled in a brass case. The main purpose of the lamp design is to reflect minimalism to refer to futuristic visions. The design studio has several series for lighting, this year and most of them have been launched in *ICFF (International Contemporary Furniture Fair) 2016.*

Meta *by James Dieter*



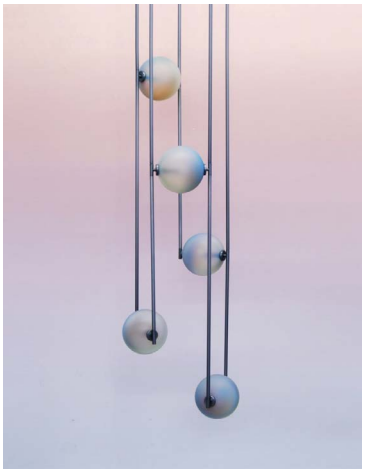
The Meta lighting system by the American designer James Dieter is made of linear lights with black capped ends. These ends are linked to each other by cast iron beams to compose different configurations. The lamp has been launched in ICFF 2016 too.

Laurent *by Lambert&Fils*

The Canadian design studio has created this lamp by balancing two glass spheres within a folded metal frame. The design is a classical pendant light. As mentioned, the material of the spheres is frosted white glass and the structure is made of powder coated aluminum, chrome, acrylic or brass panels for different variations. The collection includes a variety of configurations for the glass spheres placed on different structures. The finishing of the basis is either glossy to reflect the spherical lights or matte to emit a solid diffuse light.

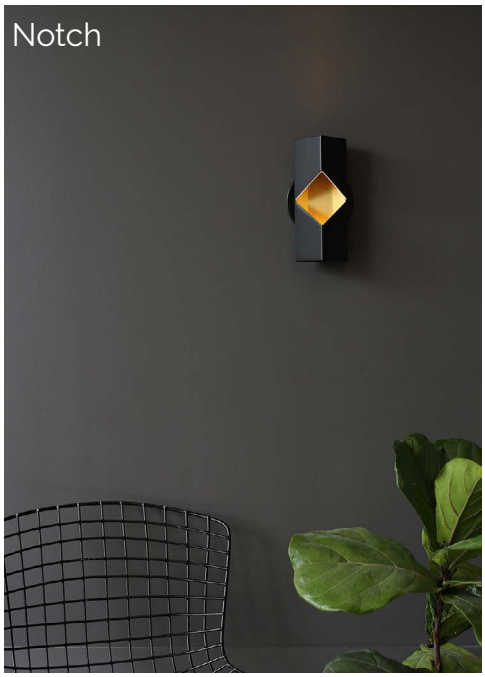
Equalizer Lamp *by Ladies&Gentlemen Design Studio*

This pendants designed by the US atelier Ladies&Gentlemen is composed of glass spheres changing color when the lights are turned on. The lights are made of customizable metal frames and frosted glass spheres containing the LEDs. The original version of the lamps uses grey-tinted glass, but these hand-blown parts have a set of colored versions tinted by using a special glaze. The metal frame is available in three finishes; dusty blue, champagne bronze and dark bronze.



Phase, Notch and Witt *by David Rockwell*

The American designer and architect David Rockwell has created a series of three lamps for the New York company Rich Brilliant Willing. The collection has been released in ICFF 2016 in New York. The collection includes two wall lights and a pendant light. The first lamp called Phase is a wall mounted light is inspired of the half-lit state of the moon. The material is glass and while a side of the lamp emits a bright light, the other side diffuses the glow thanks to its chrome coating. The second wall lamp called Notch has a cubic shape that is cut out allowing the light to be emitted through its core. It allows the light to be cast from the top, bottom and front sides. The outer surface has a black matte finish, while the inside of the brass lamp is left pure in order to reflect the LED light. The last component of the collection is Witt. It is in the form of a chandelier – which is within the 2016 lighting trends – and it is made of a spherical core framed with a hollow cube made of brass.

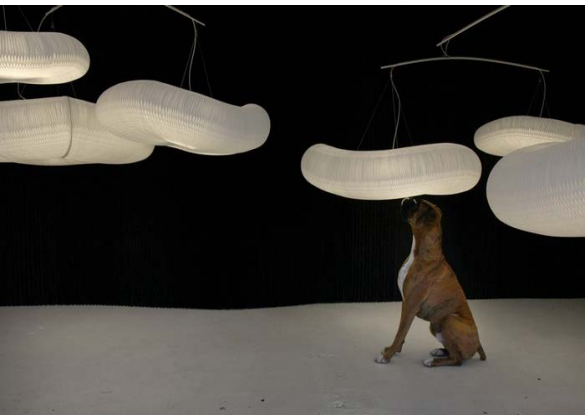


4. Examples from France, Maison&Objets 2016

Cyborg *by Karim Rashid*

During the new edition of Maison&Objets, *Martinelli Luce* has launched Cyborg designed by Karim Rashid. The lamp is made of cast aluminum and it has the paint color options as cyan, lime, grey and natural aluminum. The small lamp responds to human contact through its touch-sensitive surface. The light emitted is in diffuse form, is emitted on the bottom side of the lamp and diffused through the three legs of Cyborg. The tripod design has a minimalist look reminding a jelly-fish, according to Karim Rashid.

Cloud Softlight *by Molo Design*



Cloud lamp that is exhibited in Maison&Objet 2016 in Paris creates soft luminous forms with its soft and cushion-like design. The hollow structure is internally lit by LED light to create a mysterious radiation from any vision angle. There are three available sizes and it is created as a pendant light. Different positions can create different effects and decorations, while the number and configuration of different sizes can shape the environment differently. The only color option is white; being suitable to the trend of the year.

Tears from Moon *by Ilfari Collection*

As this year oversized and glamorous light fixtures are in trend, Ilfari Collection released their new series of pendants that are both modern and vintage. This lamp called Tears from Moon is a reflection of gothic style into modern design. The black lamp is made of hand-blown glass pieces and uses LED lighting for the candle-like light sources. The pendant reminds the old style chandeliers (Trend n. 6) but it combines the past with the future, and presents a high level of modernity.

CHAPTER 5:
DESIGNING THE EXPERIENCE

Definition of UX and UI; Important Methods to follow and Product Categories with a Benchmark Analysis

5.1. An anlysis about the Possible Needs of Habits of the Target User about Lighting

Lighting design is a science and an art determining the relation between the user and interior. It's a science because there are many data concerning to the physical and psychological effect of lighting on people. It's an art because it contains design in it, the aesthetics and subjective aspects are included.

The main mission of lighting design is to make people feel good and comfortable. The scientific researches prove that a good lighting in schools leads to effective learning, in offices to effectiveness, in hospitals to the recovery period of the patients. Lighting design has many other positive effects on the human life.

The first need of the user who buys a fixture or system is to lighten his environment. The primary need is to have light when he needs it. This need totally concerns to functionality. A good lighting design can be created by understanding the needs, desires, fears, worries, life style, schedules and many other aspects constructing the general profile of the target user.

While the need of the user may depend on the application, there are some common expectations from a good lighting. Efficiency is the first aspect that people give importance. As the main function of the light is to provide seeing, a good lighting design has to consider offering an efficient lighting depending on the application that will enhance the ability of seeing.

The effectiveness of a lamp largely depends on the application. A specific application may need to dim the light, while for an application dimming can be a disadvantage. The designer has to define the specific need well, and to work on answering the desires of the user.

Another aspect that is important for customers is the cost of a lighting system. As the initial cost has a big importance for most people, the consumption is one of the biggest issues for a big amount of customers. The energy-saving has also an ecological side, but it's also related to consumption and a part of people may choose an energy-saving lamp just because of this side. But the common important point is to provide 'energy-saving fixtures' for customers. On the schema, the three main sides of lighting affecting the user are visualized.

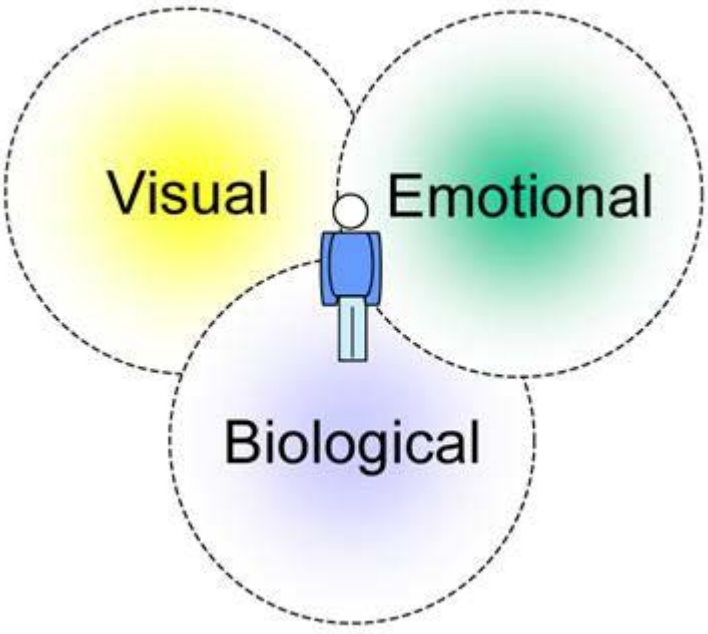


fig. 5.1

The lighting fixture or system has to be understandable and easy to use like all other product designs. In this case the control system has a big importance. The user has to be able to understand the controls and easily perform the mentioned features of the design. The methods of switching on or off, dimming the light or changing the color have to be clear. If there is a digital interface, it has to be standardized and simplified as much as possible. If possible, the need of knowledge can be avoided or decreased as much as possible. The signs and symbols that are used in the interface have to be common and understandable.

The conventional lighting is based on switching the light on and off; dimmers can be seen in some houses. This means that the user used to control the light by a physical component. So, the designer has to take it in consideration, when offering a digital interface provided by a touch screen for example. Another problem can be to offer a remote control which will make ease in the use, but which is containing a lot of different buttons on it. In this case the remote device would make the interaction much more difficult, rather than offering easy control to customers.

Psychology is an important fact for product and interior design, and some psychological aspects can be related to lighting. The quality or safety of the environment may be important for a part of users. Lighting design can become a solution for many fear and discomfort. It is an important element of interior design to make the people feel good.

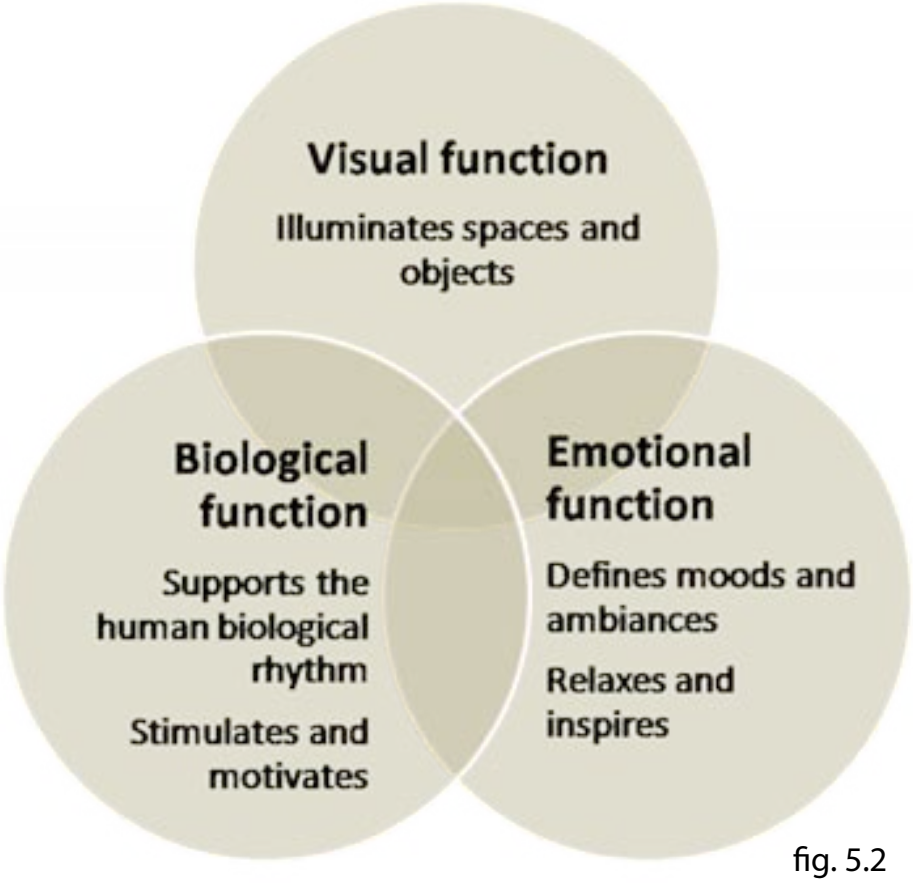


fig. 5.2

But, the use of some proven techniques for a better psychology may not concern to everybody. The designer has to be very careful when using some colors, sounds and animations in lighting. He/she has to observe the habits of the user well and avoid negative effects of new features.

In summary, for a customer, the most important need about lighting is to feel good. Beside, there may be many other needs such as saving energy, ease of use etc.

5.2. Definition and Examples: 'User Experience Design and Technologies (UX)'

Definition: 'User Experience' (UX)

User experience design (UXD) is a design field aiming to satisfy the customers with the usage process of the product or interface. It aims to improve usability, accessibility and pleasure provided by the interaction design. Basically, it is the feeling of a person when interfacing with the designed product or system.

UX is a field that is the conjunction of three areas that are technology, business and design. Here, technology includes the functionality, engineering, the foundation, the objectives, the backend, the performance and feasibility of the project, realism, complexity and establishes. The role of 'business' is to define the goals, the vision and the budget. The design side is about the aesthetics, the creativity and abstraction, other visual aspects and clarifications.

These three fields show three more important components of user experience design and these are "efficiency", "effectiveness" and "branding". Efficiency is goal driven and shows the level of the functionality achieved comparing with the design objectives. The effectiveness is about the usability and interaction level. Branding is another issue that is related to marketing, company profile, advertising, communication etc.

The important aspects to be considered for UX designers are usability, human factors, design, utility, accessibility, HCI (Human Centered Interaction), marketing, ergonomics and system performance. The main aspects that determine UX are 'human emotions'. So, a UX design has to be basically "cool", "beautiful" and "interesting".

The UX designer's mission is to study and evaluate the feeling of the user about a system, considering the features as ease of use, perception of value, efficiency and other factors that are mentioned before.

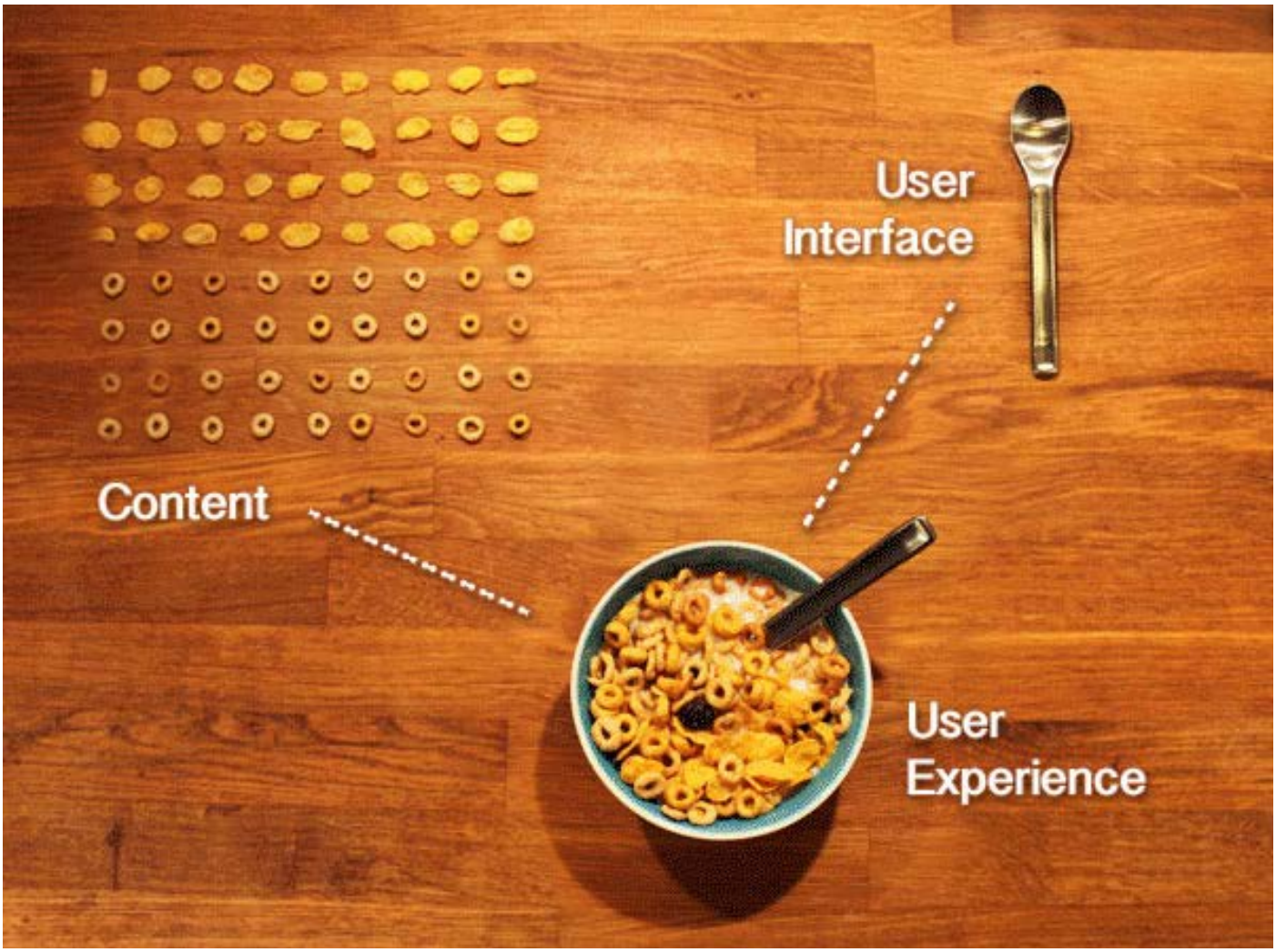
The key aspects to provide in a good UX design are 'humor' because the users remember humorous features more than the serious things, 'recognition' because people tend to see more the aspects that they are already interested in, and 'pattern'; it is easier to recognize repetitive features.
Nowadays, the user centered design aim has been so popular and it can be unnecessary to question or try to justify the importance of UXD. However, it can be explained that the main importance of user experience design is to deal with the needs of the users.

The user experience implemented in a product, the quality of the interaction is highlighted not only with the product itself, everything about interaction gets important, such as the design and planning of the advertisements, the look and effect of the UI design of the website, the main properties and functions of the designed product, the usability, usage experiences and even the label placed on a single button.

Designing UX is to design a non-physical aspect that can be defined as "what is going to be when the user enters in an interaction with the object". Of course this definition seems valid for product designs, but it is adapted in many other fields such as websites, graphics or other software designs. In these cases, another design issue to be considered is 'UI'.

The main issue of user experience design is to understand the needs and expectations of the user, to create solutions for them and offer more enjoying times when interacting with the service. Another mission of UXD is to enable positive emotions of the user through the product interaction.

As an important issue, the term UI is usually confused with UX, but they are actually very different terms. UI is the design of the interface, while UX is the design of the whole experience. UI can be used as a tool for UX design, while UX is a wider design field. To perform a UXD, there are some strategies and tools that can help to the designer to build a richer experience.



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The Elements of UX

1. The Surface – This is the visual design of the interface, UI.
2. The Skeleton – It includes the frame of the project, the interaction patterns, the global navigation etc.
3. The Structure – It is based on the construction of the needed information and definition of content.
4. The Scope – At this stage the functionality, useful features, requirements etc. are built.
5. The Strategy – This means taking the business requirements, the needs of the users, the goals and such aspects in consideration.

5.3. User Experience Design Strategies

The first step to design the experience is to define the main important aspects of the project. These can be listed as:

1. **User Definition** Who are the users?
2. **Problem Definition** What are the problems of the user?
3. **Possible Solutions** What solution could be proposed?

For a sustaining innovation in user experience, the problem should be understood well. The market research is very important and it has to be done at the beginning. A high level innovation has to improve the performance, cost issues and the incremental changes. The cost has always to be considered and kept as low as possible to reach the marketing goals. The needs and expectations of the customer are the first constraints. Risks have to be avoided from the business methods to be used. The cycle of constructing the experience passes through 'learning', 'creating solutions' and 'testing the solutions'.

The aim of UX design has always to be considered. It is a mentality focused on value commitment and inspires from the ideation. The design decisions are guided by the design of the experience. The strategy of design has to be planned through these aims and features of UX.

The Five Elements of UX

Concrete

Abstract

Surface
The element that brings everything together visually. It consists mainly on 'Visual Design'

Skeleton
The element that makes everything concrete. It's mainly based on the 'Interface Design (UI)' and 'Navigation Design'.

Structure
The factor that has the mission of shaping the scope. It consists of 'Information Architecture' and 'Interaction Design'

Scope
This step is useful to obtain the requirements by the transformation of the strategies. Two categories are obtained: 'Functional' and ' Content' Requirements.

Strategy
This is the starting point of the design processes. It consists of understanding the target user and the business needs.

The UX design process starts with the user. Once the target user and usage area are defined, the next step is to understand the needs of him. At this stage the expectations of the company are also important and have to be taken in consideration. With all these constraints, the use, which means the experience, has to be determined. The features of the experience and the product or service are defined depending on the defined use. After solving all these steps, the user experience for the target product is created.

Storyboards and personas are very useful tools for a user experience designer. A storyboard helps the designer to see the problem much clearly and the persona helps to classify these problems. By creating these two tools, the designer will be able to see and define the biggest and most important problem in the scene.

When defining the target user, it's important to be specific and determine all the details such as the gender, age, city/country where the user lives, the family structure, his/her job, economical situation etc. These specific characteristics would be very helpful when constructing the functions of the product.

Empathy is the essential feature for a UX designer. The designer has to see the needs and feelings of the customer and the final user to add the right value in his design. So, the designer can make a list of features for the product. These limited features are useful for supporting the use; these are not the main features of the product.

It is important to test the use, and it is possible by using metrics. These metrics can be graded in five levels such as "unhelpful>vanity>good>better>awesome". A good metric measures the usage of the product by the help of a person. The usage has to have specific features that
delivers the value correctly to this person. A great metric has to be able to avoid all the other possible numbers at the first try.

The metrics can be verified through some layouts. The first question has to be about beginning with a number or not. This can be a number showing an amount, an average or a percentage. Secondly, the metric can be based on time such as days, weeks or months. Then, the basis can be an object too. After the verification of metrics, a dashboard will be created to assess the process more easily. This helps the designer to see how the success looks like.

After all these assessments and work, the designer will be able to see and show the total story and to design the final product. Three objectives for the project appear at this stage: to make the product as the customer wants it to be, to avoid iterations and increasing costs, to reduce waste (of time, of energy, of material etc.).

For an easier and more efficient UX design, some practical ways exist as tools for the designer. By using these methods, the design process would be easier and organized well:

1. Use of basic supplies
2. Organization of ideas
3. Going from wide through narrower
4. Creating individually and freely, but discussing as a team (3 people is ideal)
5. Working at the wall with sticky notes of ideas
6. Reading quietly the ideas before the discussion
7. Sketches including the user (human)
8. Relaxing and giving time to the job; speed causes mistakes
9. Making quick decisions for short-term applications; these can be tested and changed after
10. Testing the ideas frequently

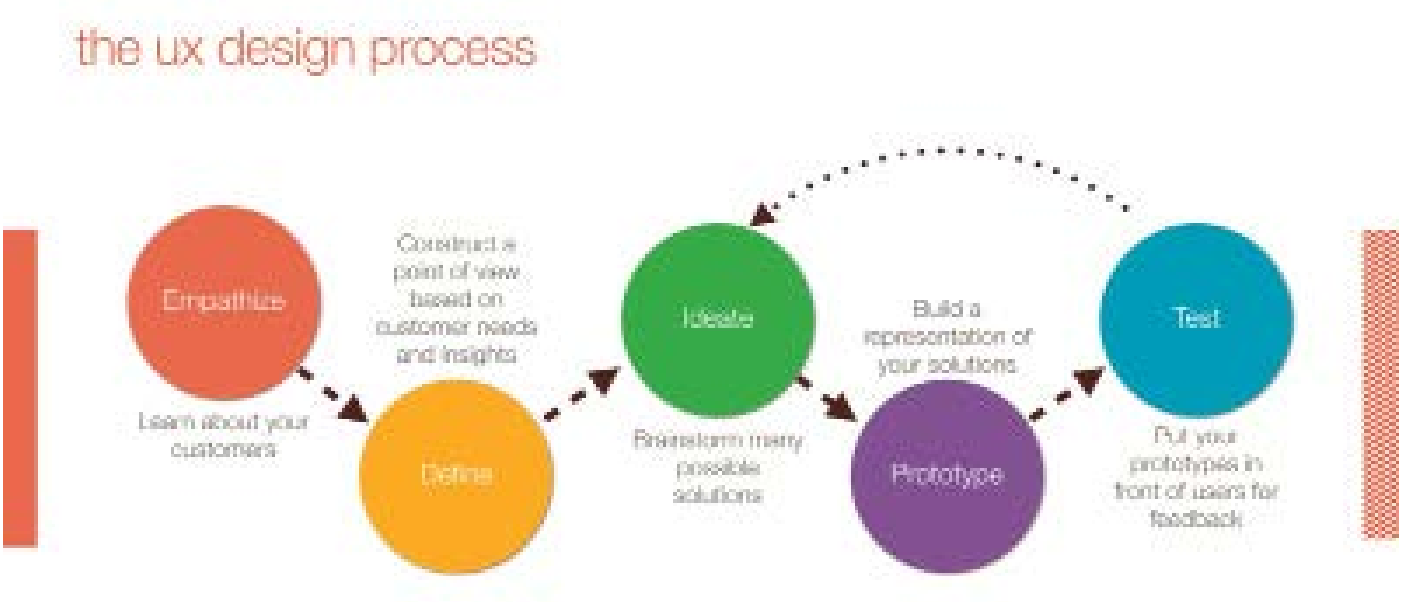


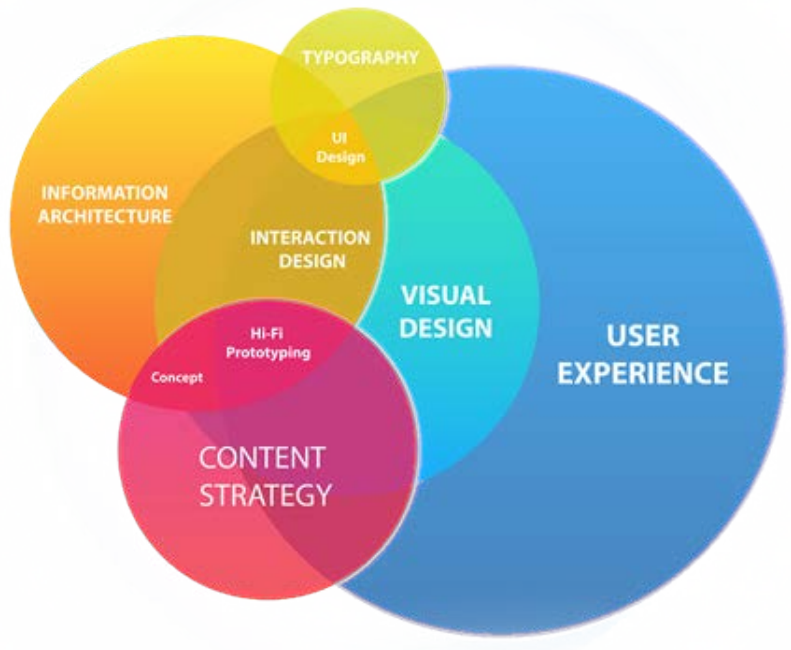
fig. 5.3

"A good design of UX is based on continued testing and improvements about the product or service."

Influence of design in UX

Visual features are very important in user experience design and especially in UI. Design has to be made to help people to recognize familiar elements, because people tend to associate some behaviors with specific appearances. The role of the designer here is to catch these key points and implement them into the designed product.

For example, naturally, for human vision, rounded shapes are easier to perceive and softer colors are more pleasing such as a soft blue. For these, it can be recognized that the products of Apple Inc. have always a shape of a rounded rectangle and the colors of their software are usually white, fair gray and soft blue. This can be a reason why most of people choose this brand even if they are not really convinced with the functionality and total design.



5.4. Smart Products for an Advanced Experience

5.4-1. Definition

Recent developments in micro chips, sensors and other digital technologies changed and are still changing the consumer products. This allows the physical products to be filled and enhanced with intelligence, sensing ability and communication skills. This comes up with a new category of product design that is called 'Smart Products'.

The smart products have a high level of interaction for their control and entertainment and they became very popular in recent years. These products need an efficient UX design in which user interface (UI) has a big importance.

5.4-2. Categories and Examples

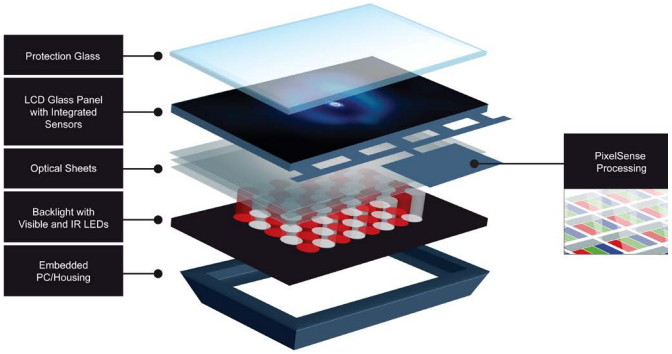
Smart products' technology has developed very quickly while it still has missing technologies for advanced applications. In this title, the smart products will be categorized and exemplified to see and understand their importance and efficiency in the daily life.

2D Sensing: Smart Surfaces

A smart surface is a physical device that is able to 'intelligently' manipulate the objects that are placed on it. They don't have a formal definition while they can be categorized depending on their functionalities:

1. **Sensors:** A variety of sensors are available in the market in order to detect and react to the objects placed upon them. These can be global or distributed sensors.
2. **Control System:** the features of a smart surface may be classified by the control system that offers the possibility to identify the object or measure the position or orientation of the object placed on it.
3. **Manipulation:** A specially distributed actuation makes the coordinated physical manipulation possible such as an array of actuators that uses vibration, magnetic levitation, air current etc.

These digital surfaces allow to be touched by one or more persons at the same time, while some variations are able to detect the real world objects. They are also called as 'Interactive Surface Computing Platform'. They are able to share digital content and they usually use a multi-touch PC hardware.



These devices require specific hardware components. One of them is the use of IR (Infrared) sensor. These sensors are able to sense visually what is happening around the touch surface. This provides the possibility to the system to sense and interact with any real world object that is near. This doesn't require specific objects with conductive surfaces – Such as with capacitive touch screens – and high physical pressure – such as resistive touch screens —.

As seen in the figure, the smart surfaces are composed of numerous layers. These layers are usually (from bottom through the top);

1. The Polymer Housing (usually PC (polycarbonate))
2. The Backlight (composed of visible and IR LEDs)
3. The Optical Sheets and the Pixel Sense Processing Module
4. The LCD Glass Panel and integrated Sensors
5. The Protection Glass

fig. 5.4

3D Sensing: Gestures

fig. 5.5

This category includes the "3D Depth Sensing" and "Face and Body Tracking Solutions". The gesture recognition technology is based on sensing the human motions by a computing device. The gesture recognition includes the facial recognition, eye tracking, voice recognition and even the lip motions' recognition. The obtained data by the controller device is then sent to the computing device and visualized in order to control digital objects and features by real physical movements.

These controller devices such as Leap Motion Controller visualized in the picture above, are based on the use of accelerometers and gyroscopes to sense tilting, rotation and acceleration of the moving body part. There are many other companies producing controllers using this method.

As these technologies can be used for gaming and entertainment, they are used in daily life as well. Currently, it is possible to control the Smart TVs by hand motions. A shake of hand can change the channel or turn the TV off. In this way, the performed interaction becomes more natural and easier for the user.

The process and working principle affecting the user is very simple. The user inputs a gesture by performing a posture or a motion. The sensor detects the motion, deduces it in signals and sends this data to the computer. The computer performs the task depending on the received input data and

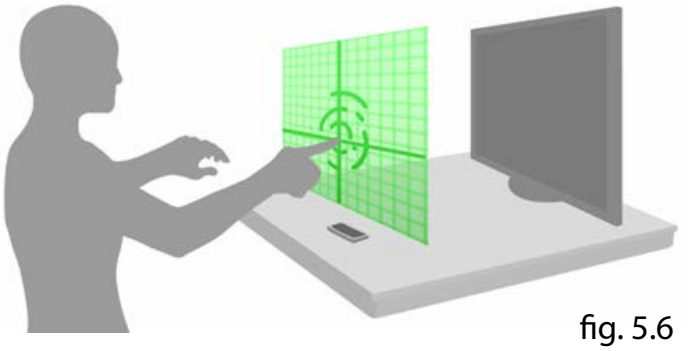


fig. 5.6

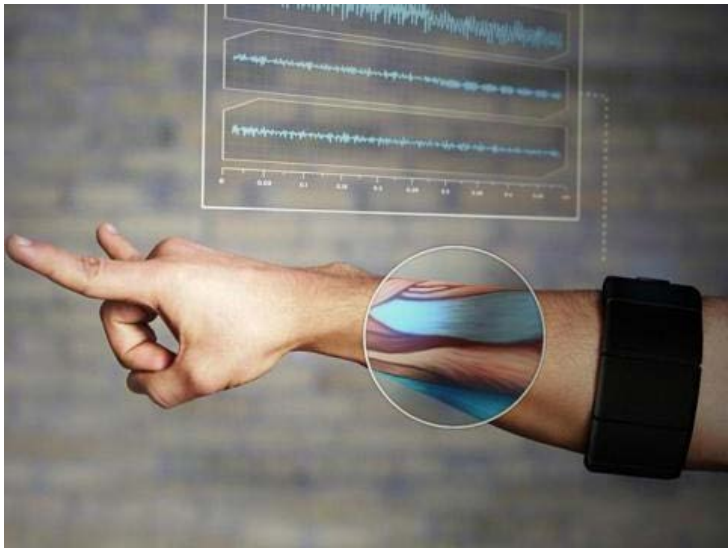
Benchmark Analysis – Some Examples for Gesture Control Devices

1. Leap Motion Controller

Leap Motion Controller is a device that detects the finger and hand motions, uses it as an input and allows the user to control the software without touching anything, only by using his gestures. The aim of the company is to offer technology to everybody, with easy use and lower costs. The device is very small; smaller than a human hand, and it is attachable to any computer by the use of a USB

2. MYO

MYO is a muscle sensing device that is in the form of a bracelet. It detects the motion via the muscles' tension and sends the data to the computing device as an input. The functions are similar as Leap Motion Controller but the technology of MYO offers more freedom in terms of moving area of the user. The aim of the company is to avoid wires or cameras for removing obstructions from the user experience. The company is backed by Intel.



3. Kinect

Kinect is the technology that allows playing games on TV just by moving their bodies' features, without using consoles, remotes or other devices. The device uses Infrared light beams to detect the motion and gesture data to send to the TV as an input. But, the device is only responsible to detect the motion and send the data; the changes in 3D graphics are realized by the XBOX software.

4. Nod

Nod is a gesture control ring that is connected via Bluetooth. It allows to click, swipe and even type without the need of an additional device, by letting the user free to move. The motion of the hand – with the ring – allows the move or change screens while the flat surface on the side of the ring is used for 'clicking' which allows to type. The ring has 12 different sizes to fit on everybody. The device is at 'pre-order' level yet and it costs 149$.

Self Learning House Appliances

The main aim of smart house appliances is to make the life in the house by using technology. The new technology of smart home appliances are able to keep the data for constructing a set of habits of the user. This creates a big advantage for the user in order to keep the level of comfort on top.

The biggest benefit of these devices is to save a big amount of energy. Studies show that the real time feedback of the devices helps to reduce the electrical consumption. This helps people to understand what consumes more energy and what device could be turned off to save money. The next level of this is more interesting. The smart home appliances keep the total control of the house and don't leave the need of care about the energy consumption at home.

These technologies allow the user to turn their houses to be "smart" by the use of single devices. These devices learn the lifestyle of the users and adjust the house conditions depending on these data and the need of the user.

These devices are usually connected to monitoring software such as a mobile application, that allows the user to check the consumption and the state of the house real time or divided in periods.

Benchmark Analysis – Some Examples for Smart Home Devices

1. Nest – The Learning Thermostat

Nest is a smart thermostat that has the vision for reducing the waste of energy consumed in a house. It has a round shape and a simple control such as a dimmer switch, and its interaction and UI are very simple to be understandable by everybody. The temperature can be set easily by rotating the outer ring and the thermostat is supposed to program itself, depending on data that it learned from previous uses. It keeps the settings that are realized by the user and uses them to create a periodic profile. This programming allows keeping the environmental temperature comfortable, without wasting energy.

2. Knocki

Knocki is a device that can make any surface "smart". It is easily installed and activated and it can be used for any application. For example, it can be used to receive a notification when the door is knocked, by placing Knocki on the door. Or, the TV and other devices can be turned on or off just by knocking on the surface that Knocki is placed. This device works by sound activation and aims to offer comfort to users at home.

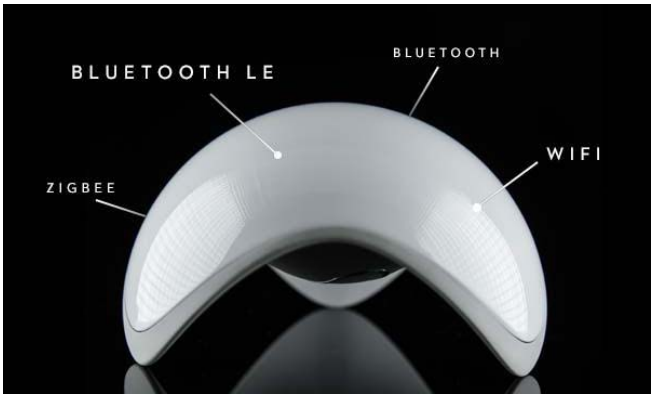
3. Jibo

Jibo is a home robot that takes the life at home under control. It is able to communicate with people naturally and it can be connected to house systems such as security, lighting, heating and kitchen appliances. It has face tracking technology, so that it recognize faces and follows the user. It can be used for scheduling, phone calls, security monitoring, light switching or dimming and even for entertainment. It's a very smart and intelligent robot that makes the life much easier

As its aim is not to be a smart house appliance or system, its features help the user turn the house into a smart home. The main aspect of the robot is to provide natural social interaction with the users, but this friendly interaction has many functions providing intelligence at home applications.

4. Ninja Sphere

Ninja Sphere is a smart monitoring device for domestic use. Not only a security system but being a device allowing the user to control the other devices easily, Ninja Sphere's system consists of Spheramid gateways, waypoints and smart power sockets. Using three or more waypoints, the system becomes able to locate the user, the pets and other people in the house. Depending on this location data, the system is able to make adjustments in the house such as turning the lights on/off, notifying for calls on the TV screen etc. by using the integrated sensors; it is able to monitor the temperature, energy consumption or anything else that is desired by the user.



5. Samsung Lumen

Samsung Lumen is a remote controller that is able to maintain all of the electric devices at home. The development in technology brought a variety of devices to be used in the house, but the control of these devices, one by one, becomes difficult for the end users. To solve this, Samsung developed Lumen, by which the user can control the lighting, the TV, the kitchen appliances and even the security system.

The device includes a camera for monitoring and provides Wi-fi connection without the need of an additional modem device. The product is still at the stage of a prototype, but Samsung Smart exhibitions proved that Lumen will be released in a short time.

CHAPTER 6:
DESIGN DEVELOPMENT

The steps and the assesments of the Design Development Process

6.1. The Needs and Strategies for the New Lighting Design

6.1-1. Simple and Understandable Interaction

As all the product design works, a lighting design has also to be simple and understandable, because the mission of a designer, without mattering to the field, is to design for people. The human factors, both physiological and psychological, have to be met in the center of the design project. Here, by saying 'simple' it's meant the ease of use of the designed product.

As a product, a light design should be created by offering a solution concerning to the usage processes. The simplicity which can be determined also as 'avoiding complexity' is one of the essential methods to ease the use. By avoiding complexity, it is easy and possible to create a product understandable by everybody.

At this point, it is necessary to clarify the term 'understandability', which is, here, the allowing of the product to be used by everybody, without having limitations about the age, language, culture and knowledge of the target user.

The new lighting design LUVI is departed from these two main aspects. Even on the very early ideations, it was obviously defined to create a very simple usage process to obtain the desired function, for the customers' comfort.

A simple light design is actually very easy to create; the simplest way of using a light is already present in the life. To switch on/off a light by using a button or a switch is the most common and the simplest way, while dimming my be the second simple way to control a light. So, from the technical point of view, there are a lot of techniques and components that could provide a simple control for a light system, as mentioned in this dissertation for several times.

However the aim of this dissertation is not only to design a simple light fixture that is completely functional, but also to improve the user experience. At this point, the importance of 'interaction design is highlighted. While for this dissertation it is important to design a fascinating experience, the mentioned strategies has to be followed as well. So the objective was to design a pleasing experience without losing the simplicity and the understandability.

As well as the use of the physical object, for this project, it was necessary to provide these two features within the design of the User Experience (UX) and the User Interface (UI). The user experience's one side would be provided by the use of the object while another important side is the interface. So, the design had to be made of two parts, one is coming from functionality and the other from the entertainment.

Again here, for the interface the strategy would be to get a 'simple' and 'understandable' use for the customers. Now, it is more important to create the understandability without differing the age, language, culture and education.

So, the lighting design that will be the result of the whole thesis, should carry an enhanced experience for its target users. The interaction and the basic functions should be as simple as possible, while the possibility to convert the design into an interactive experience should always be present.

To summarize this part, the aim of the simple and understandable interaction can be declared as to provide a light design that can be used by everybody. Plus, the other main aim of the project is to provide 'speed' and 'fun' within the intense and fast style of the modern life.

6.1-2. Friendly Look and Concept

As a design choice, it was necessary to provide 'friendliness' of the product. This word here, means to be approachable by the users. It is desired to create an object that the customers would not hesitate to use it, or abandon the product after a while because it makes difficulties during the use. A good example for these situations could be to be afraid of use a device because of too many controls placed on the product. Obviously, complexity is one of the primary reasons of product failures.

The LUVI concept then, has to consider looking easy, friendly and also suitable for domestic use. This can be done by the form, color, size and many other design tools to be used. A choice to avoid the unwanted scenario, was to avoid control components placed on the product itself. This choice directs the project to a remote control concept naturally.

The concept or the experience, however, is a more complicated fact for interaction designers. It has to be exciting and fascinating but in this case, for domestic lighting design, it has also to be simple, practical and friendly in terms of visual and gestural factors.

The friendliness of the concept has also to touch to the psychological factors of human being. Usually, to enhance the emotional side, is a good solution to provide an emotional contact between the user and the object.

So, the second important stop of the design process, was to avoid complicated aspects that might make the user avoid using the product, or some features of it. It was necessary to build a minimal and soft interaction.

6.1-3. Multi-Functionality

From the designer point of view, for a light design, it was necessary to provide the possibility of multi-use to the user. While lighting is a need, it has several areas of uses and the new technologies offer a variety of opportunities to the designers. By using these technologies it is possible to create light designs answering several needs by a single light fixture.

During the design process, the multi-functionality became one of the main characteristics of the new design. It is advantageous to offer the possibility of choosing to the user, because it enhances the attractivity of the product and the interactive processes.
To make the choice or to switch between modes, the user enters in several interactions with the product or service; and this is the main aspect that makes the user experience more satisfying.

So, the multi-functionality would be used as a tool to interact with the user and to create a more satisfying, more attractive experience for the design. This multi-functionality could be made by mixing two different layouts of light. However, for this application, it has been chosen to create two different usage scenarios by mixing the functionality and the entertainment.

The multi-functional concept of LUVI aims to reach a wide user group having different needs, tastes, field of interests, houses and budgets.

6.1-4. Connectivity

Nowadays, most of consumer products are based on connections providing a better user experience. The technology is used to avoid cables and the cable connection is replaces by other methods such as Wi-fi, Bluetooth and many other techniques. The connectivity is used in this project as a tool to make the three design choices possible and more efficient for the use.

Some features of the planned product require some connections in order to realize them. For example, by avoiding the control components from the main object, the need of a remote control has been created and 'remote' is directly related to 'connection'.

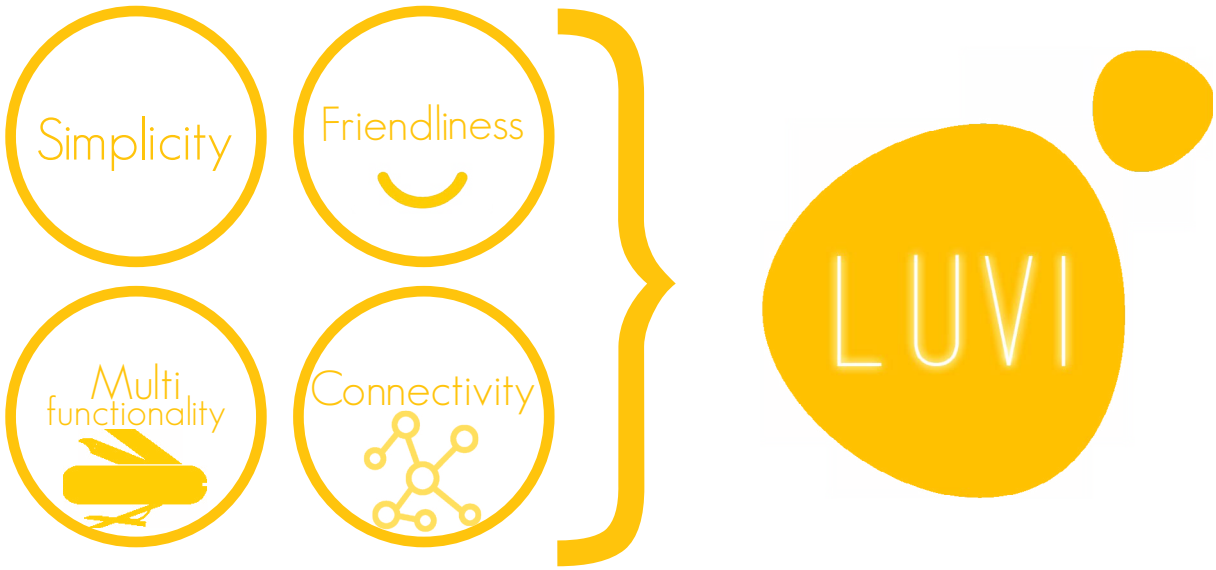
Plus, the planned light design was consisting on the wall and ceiling configurations – while the ceiling version is abandoned later – and for the user, to reach a lamp on the ground or on the ceiling is a difficult mode of use. As mentioned before, the conventional connection methods such as the wall mounted button switches or dimmers, are not interactive in the modern sense and would be avoided for an enhanced user experience. So he connectivity with an external device was necessary to offer an easy and interesting control of the light.

While telling about connectivity, it is necessary to mention the mobile applications as well. First of all, in this project, the app control is avoided from the beginning. Nowadays, almost all the digital products have a connection with a mobile application and most of the light fixtures in the market are controlled by an app. So, this technique became a very usual method for interaction.

Plus it cannot be dismissed that the design of the mobile applications covers a big part of interaction design in the contemporary visions. However for this project, it's been desired to obtain a different mode for interacting with the designed light fixture or system.

By the way, for the new way of the interaction of LUVI, it was necessary to implement a connective system into the product. So, the connectivity is an important part of this project while it is one of the design strategies of LUVI light design concept.

Summary of the Design Strategies



6.2. The Concept

The new light design concept LUVI consists on the small modular lamps aiming to avoid the user stay in the dark, when he/she arrives home or during the night. The design considers creating a light to guide the user in the dark without disturbing the eyes which are very sensitive in the dark, with a sharp and intense light.

The idea at the beginning of this project was to create light guides in order to make the user comfortable without staying in the dark and disturbing his/her eyes by using a conventional lighting. This would also disturb the other people in the house who are sleeping at night. So, the idea was to inspire from the guide lights of the airplanes and to use a similar effect to guide the user moving in a dark house. The guide lights would also create fascinating effect in the room which can also be used to create different atmospheres.

The guide lamps can be installed easily without the need of infrastructure or reconstruction. For this, the final design consists on modularity and an easy plugging system, which makes the design able to be bought and used by anybody and any house.

By these modular lamps that can be easily plugged and used, a functional light is provided for the user. To create the precise light strips have been created by designing the optical system placed into the product and the desired effect for the night light is obtained. The technology used for the optical system was offering additional possibilities and these are used to enhance the interaction.

The modular lamps are designed as wall light fixtures producing precise light strips on the ground. The early configurations of the product were both in ceiling and wall lamp layout, while the ceiling version is avoided later.

The concept is divided in two parts. The first use of the lamps is based on functionality. In this concept, the user can easily plug and install the lamps on the wall and get a nice night lighting that doesn't disturb the eye. This concept is planned to be suitable more for small houses and lower budgets.

The second concept is using the same modular lights with the same configuration by adding an interactive control panel and new functions. In this case the lamps can be used also to create a nice and different atmosphere in the room, by using the precise light strips projected on the ground.

Finally, the LUVI project is a light design cncept, divided in two modes of use in order to acces different user groups having different living spaces, different needs and different budgets.

6.3. Characteristics of the Conceptual Product

Small Size

The new lamp is aimed to be as small and compact as possible in order to ease the use and installation. The main aim was to create a product that doesn't cover big spaces; so that everybody with any size of houses could by this product for their desired use.

Easy Installation

The design consists of a very easy installation that doesn't need any underconstruction. This makes the lamp possible to buy and use in any time and in any space.

Easy Use

The designed lamp is used very simply by the implemented sensors. In case if the lamps are on, the user doesn't need to do anything special, the lamp would react automatically; while turning the lamp on/off is provided by a simple button.

Adaptivity

The design concept is based on multi-functionality, which makes the lamp possible to be adapted to different needs. 'Functionality' and 'Entertainment' are the main keywords.

Modularity

The light design is planned to be modular offering the user the possibility to increase or decrease the number of the lamps used in the room. This modularity offers also an original effect in the space.

Simplicity

As a design decision it was important to keep the interaction, the use and the form of the object simple. Because, to provide an object that is aesthetic for everyone and to keep the use and the interaction understandable by everybody; a main issue would be 'simplicity'.

Sensationa and Exciting

The design of LUVI lamps are realized with the aim to attract the interest of the customers with its simple form and enhanced interactivity. The physical and digital combination of interaction is designed to offer an exciting experience to the users.

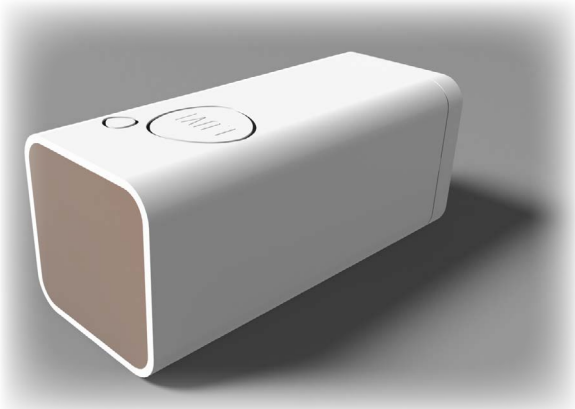
CHAPTER 7:
THE PRESENTATION OF THE NEW LIGHTING DESIGN 'LUVI'

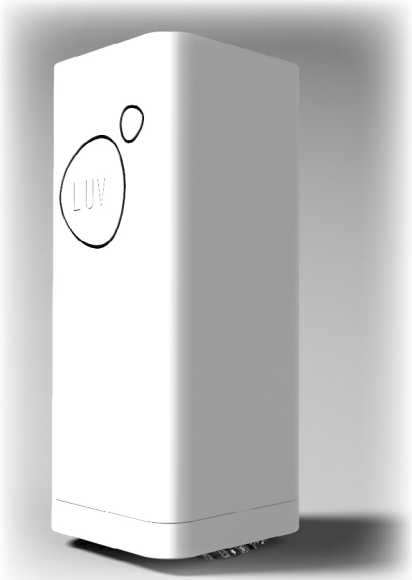
The Characteristics of the Product and
the Details about the Project

The Product and the Components of the System

The LUVI lighting concept consists of two main elements composing the system. These two components are the modular LUVI lights and the wall-mounted control panel.

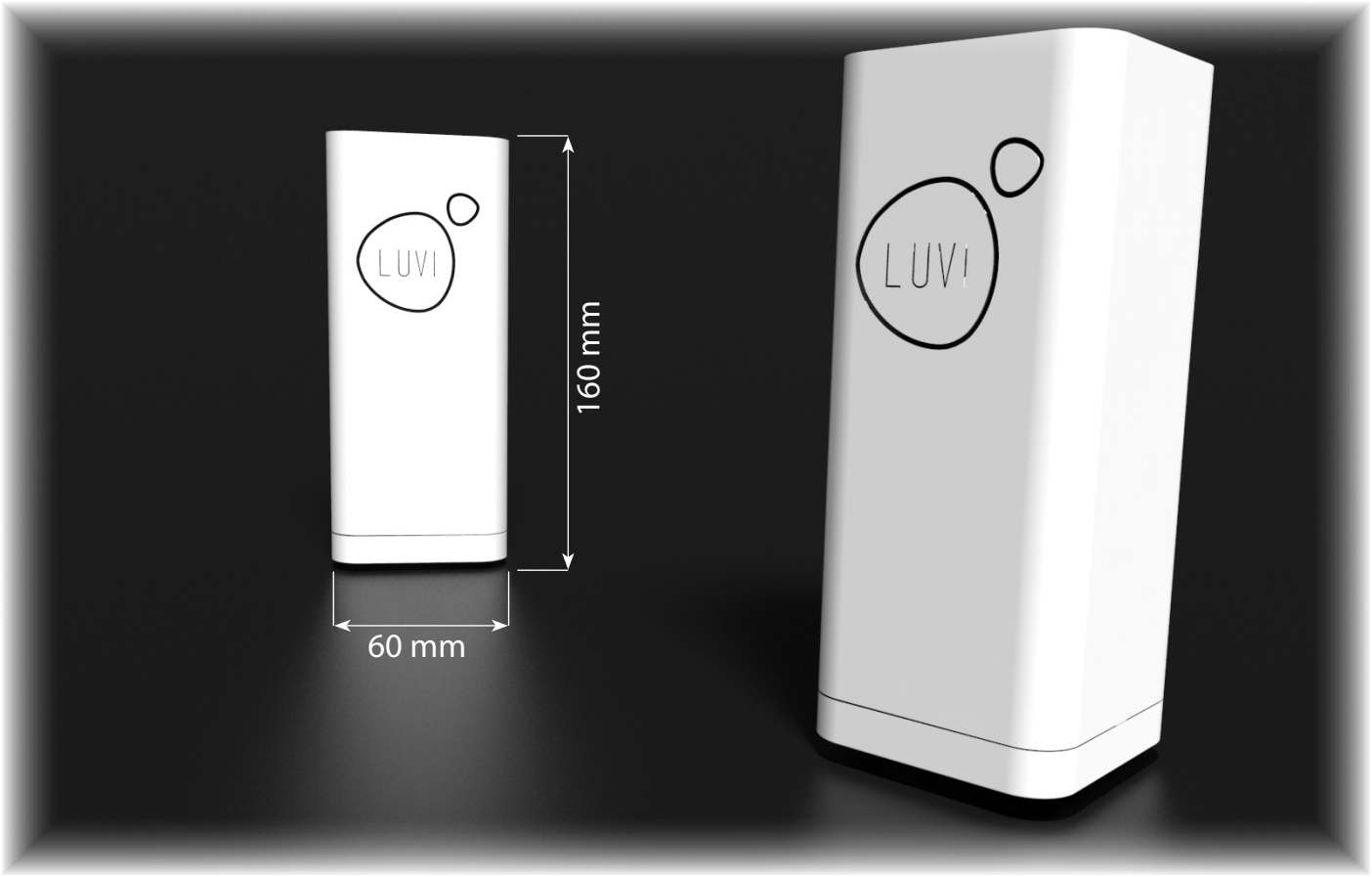
The project includes two different concepts using the same lamp and optical configuration. The first concept uses only the LUVI light fixtures in order to obtain a functional light. In this concept, the control panel is avoided to reduce cost and highlight the functionality. The second concept is more for entertainment uses and needs an upgraded equipment. In this case, the user needs to buy the control panel additionally, while the lamps are technologically upgraded as well, in order to be compatible with the control device's functions.



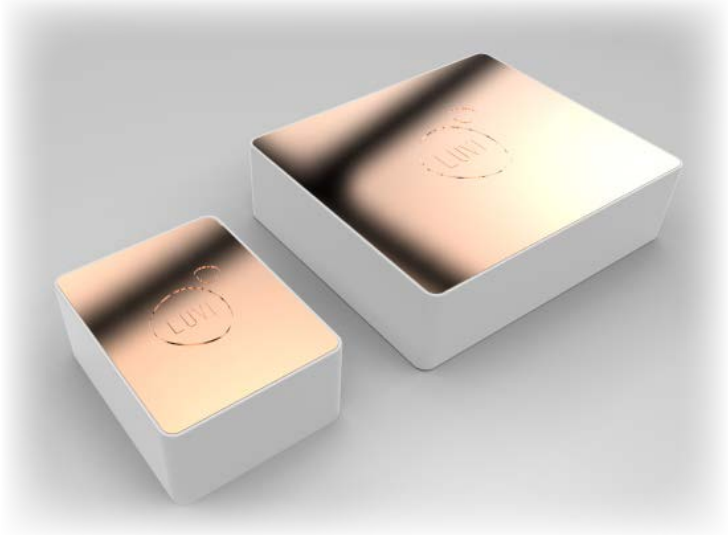


Concept 1: Plug & Play

The LUVI lamps are designed with very small dimensions, in order to provied ease in use, and mobility. In thisfirst concept, the customers need only to buy the lamps that can be used independently as a night light.

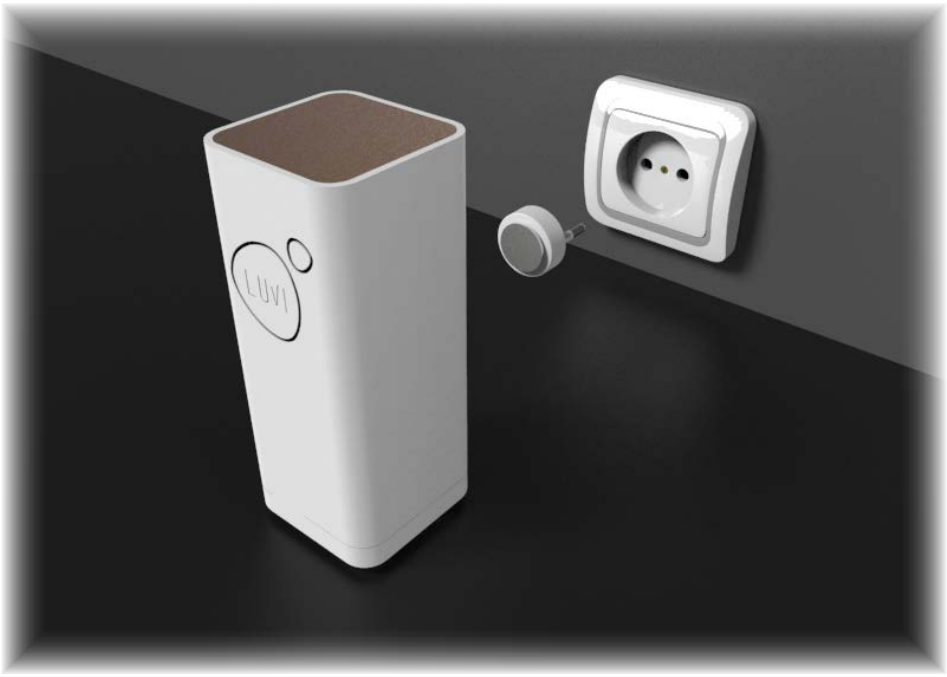


The lamps can be bought both in single and triple packagings, while the effect would be more efficient with the use of at least three lamps. The packages contain the lamp(s) and the plugging connector(s).

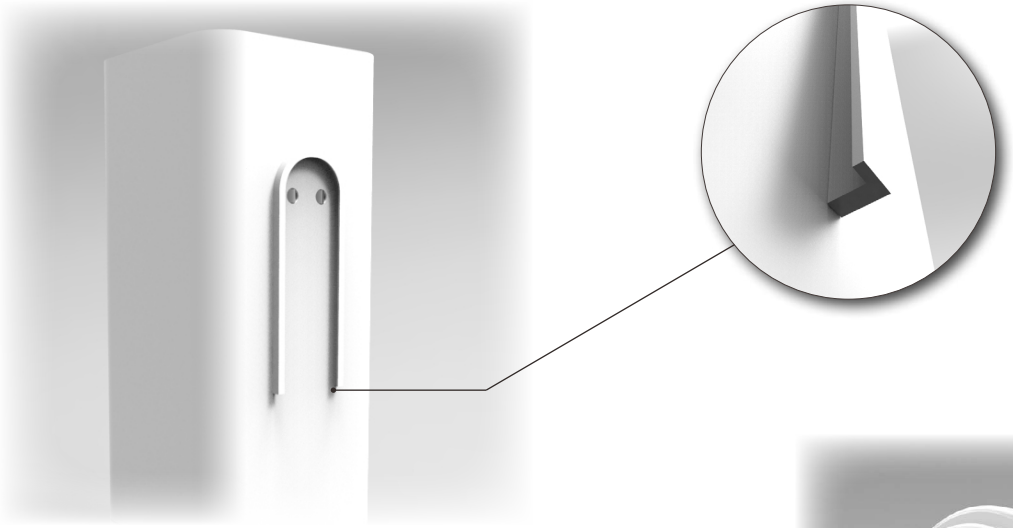


Installation

The LUVI lamps have a very simple installation method thanks to the plugging adaptor. The adaptor is simply attached to the lamp and the lamp can be easily plugged to a conventional socket.

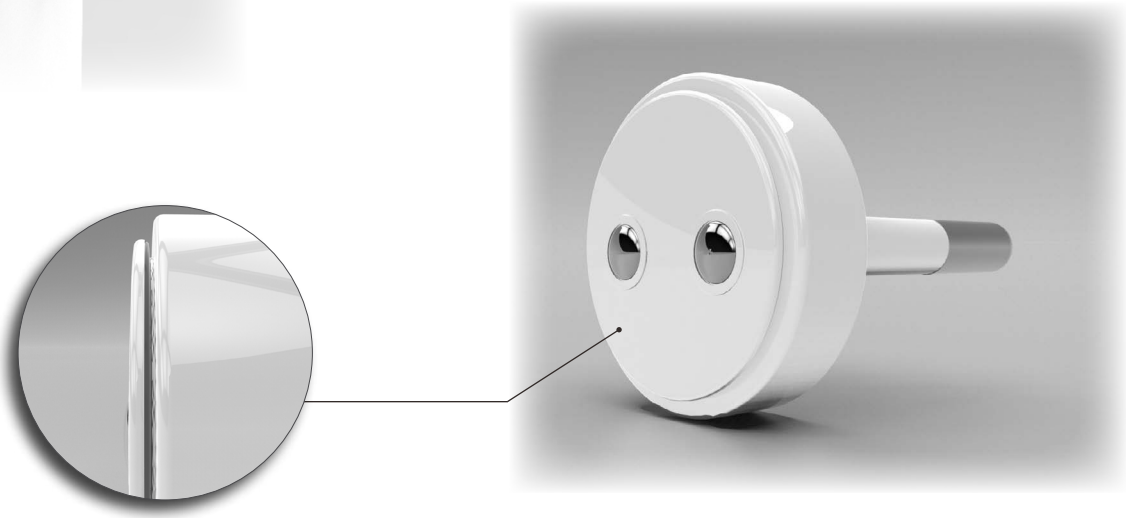


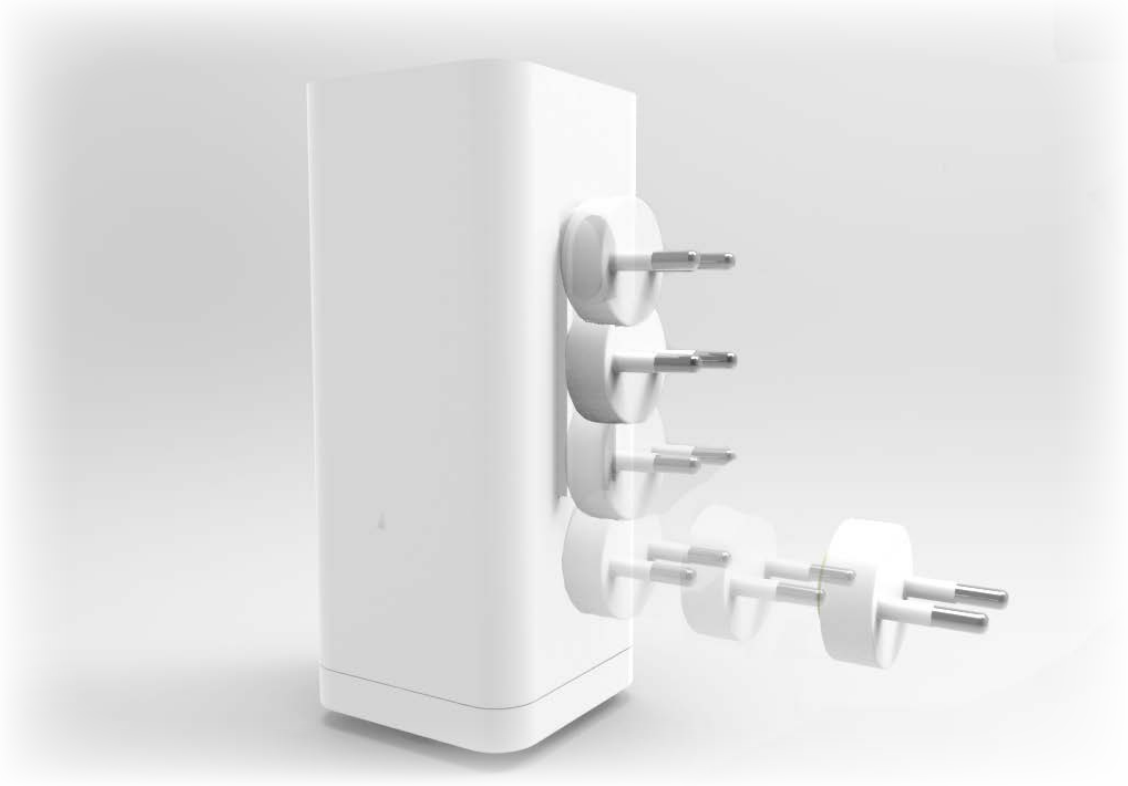
A rail is placed on the back surface of the modular lamps. One side of the electricity connector is in the center of this rail. The adaptor has the other side of the connector which is designed to fit and be locked in the rail. As seen in the pictures below, the adaptor is simply slided in the rail and



The rail is a part of injection molded shell.

The connector is designed as two layers to fit in the rail.

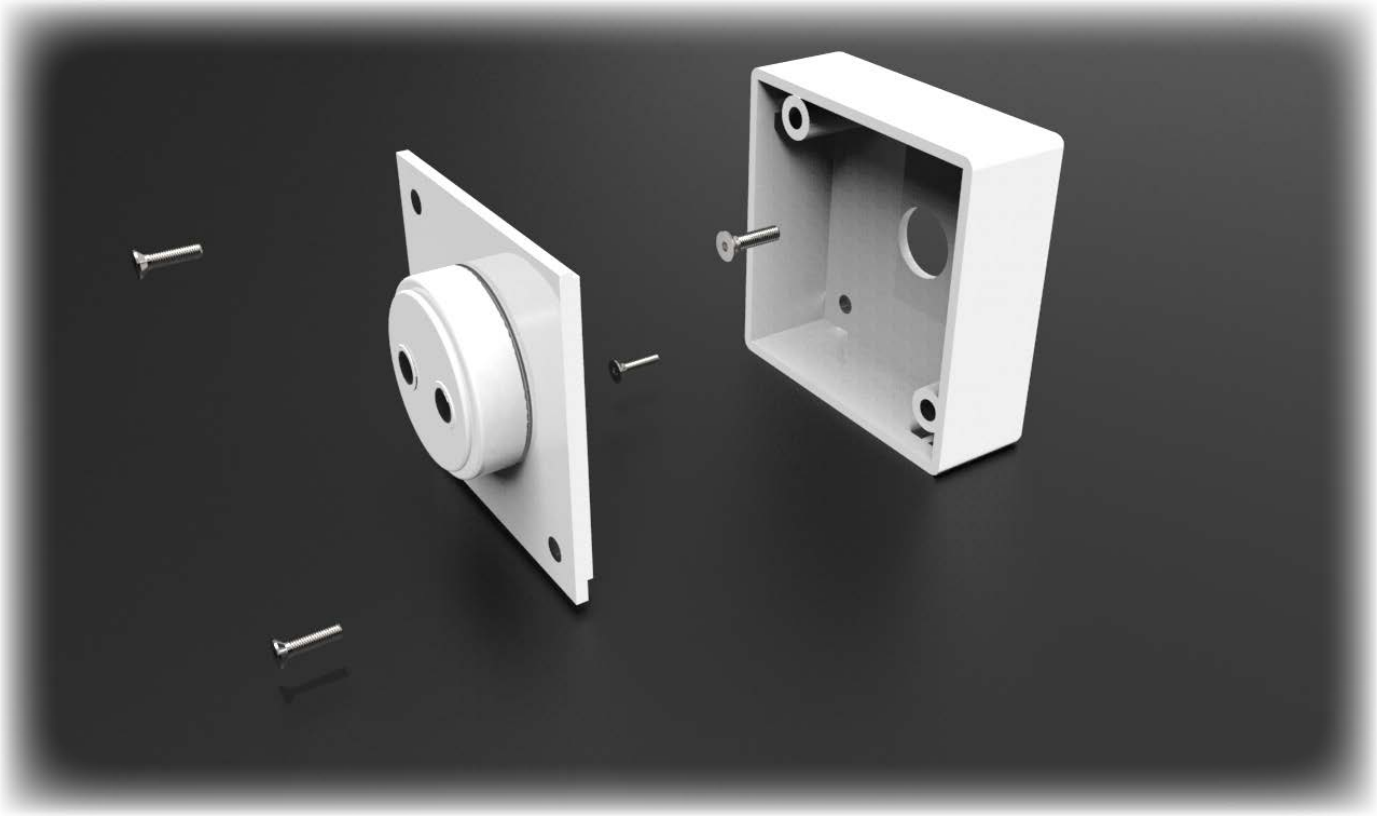




The connection adaptor is simply fitted into the rail. The user has to push and slide the adaptor up, in order to get in contact with the other conductive side placed on the back wall of the lamp. The adaptor is then blocked, thanks to the versed U shape of the rail and the cross section of the rail as shown previously.

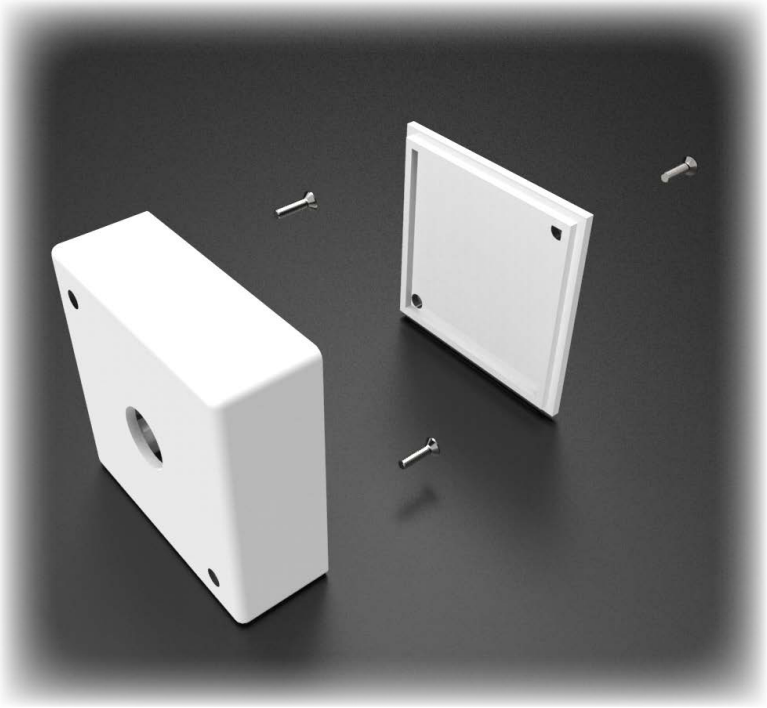
By this easy plugging method, the lamp is quickly installed and got ready to use. The final look of the lamp is as in the picture above.

Alternative Solution for Installation

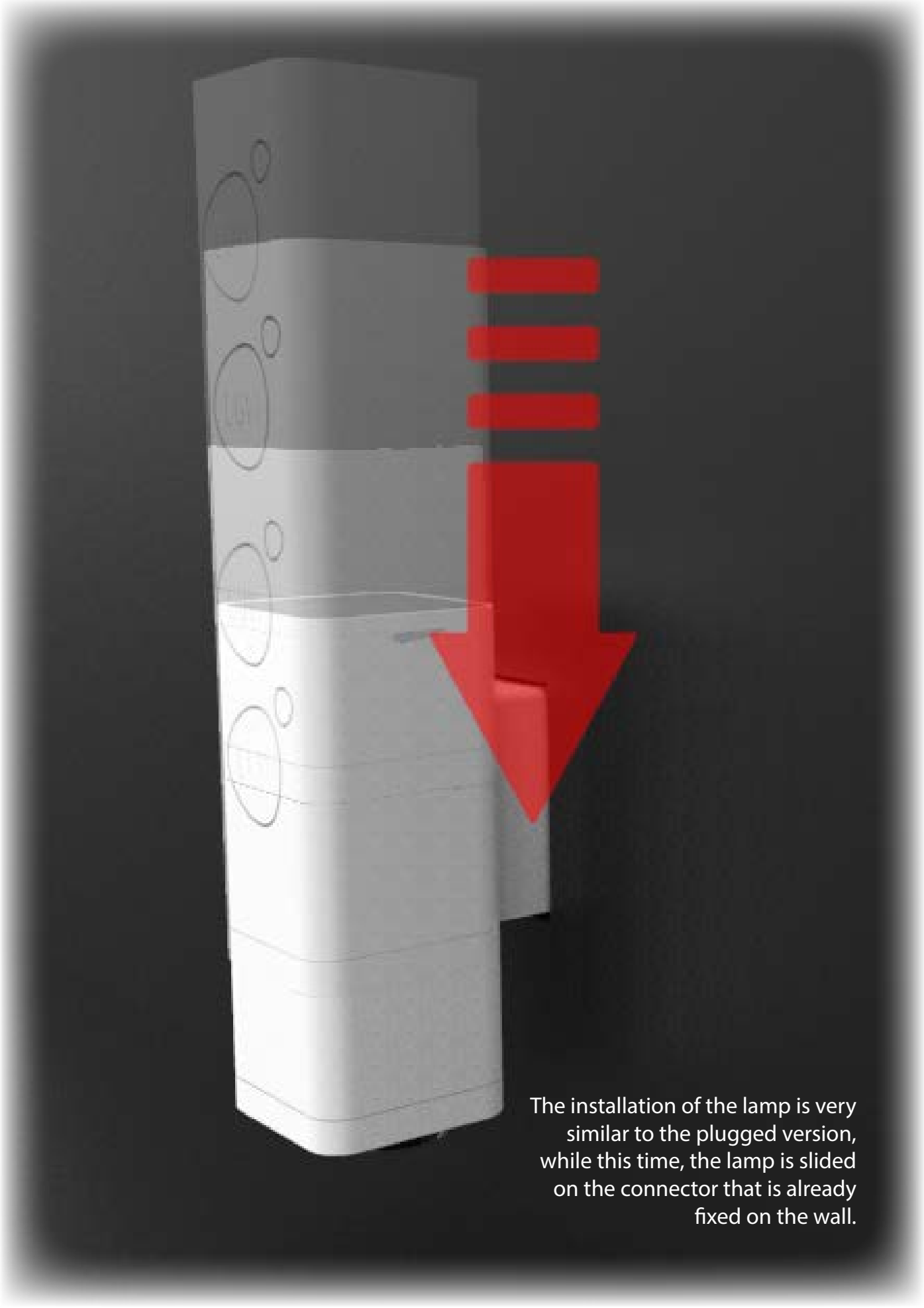


In cases if the user doesn't have enough sockets in the room facing with the desired number of lamp; another accessory is available for sale.

This mount is made up of two parts. The back part containing the cables is screwed on the wall, while the front part containing the connectors is screwed on it.



Once the mount is screwed on the wall, the lamp is ready to be installed.

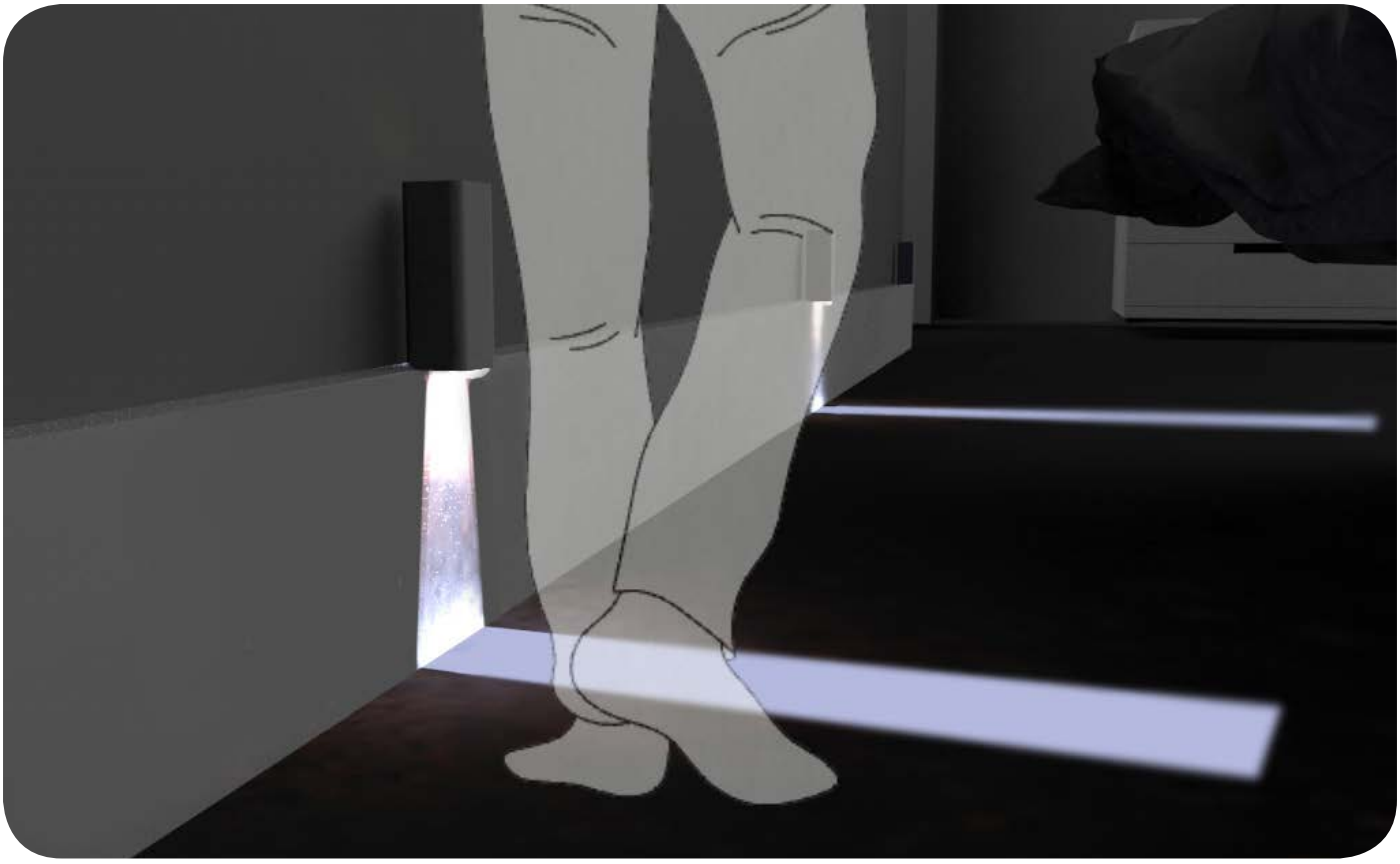


The installation of the lamp is very similar to the plugged version, while this time, the lamp is slided on the connector that is already fixed on the wall.

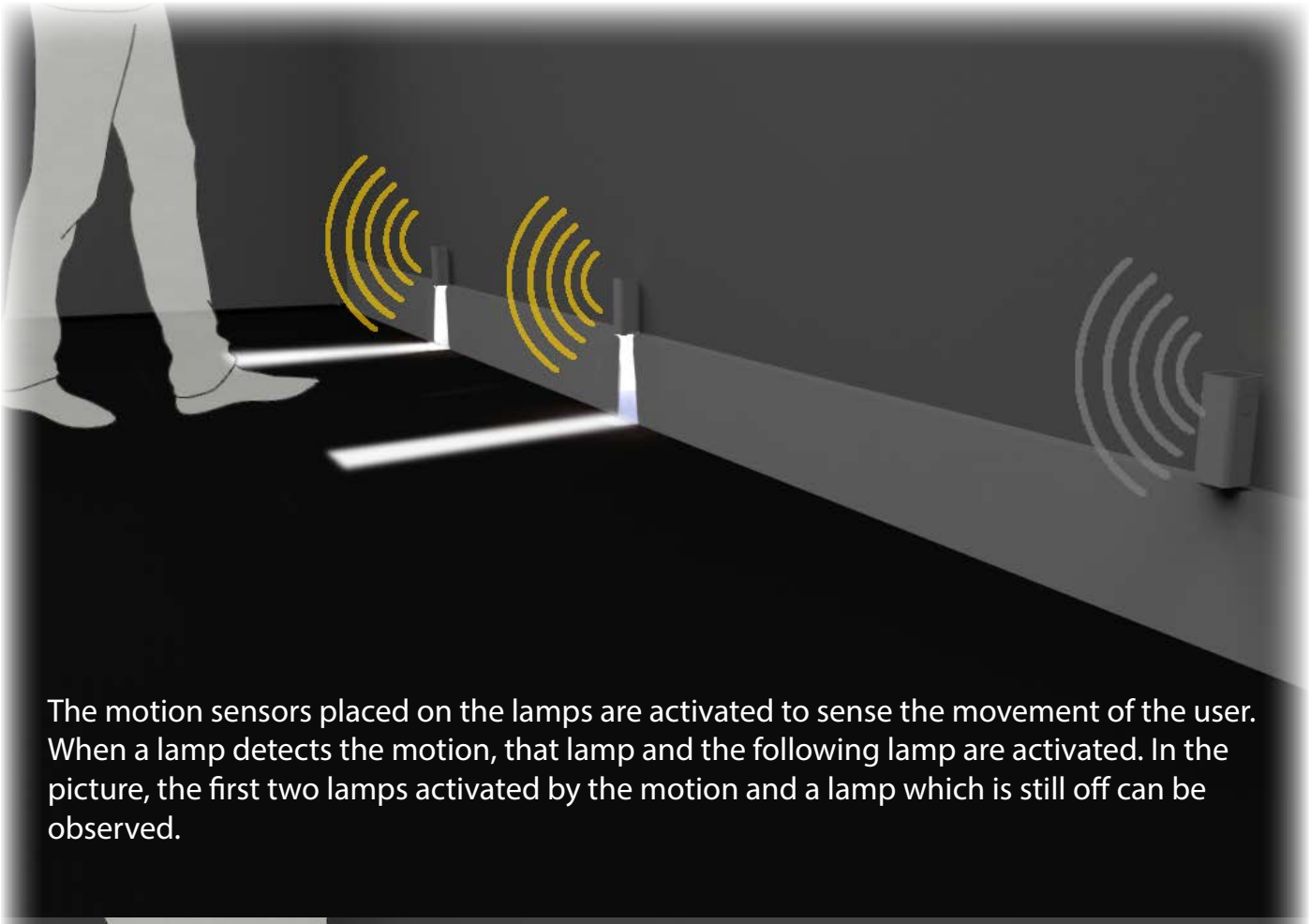
Storyboard (Functional Lighting)

1 The user wakes up in the dark room, with the aim of going to the bathroom.

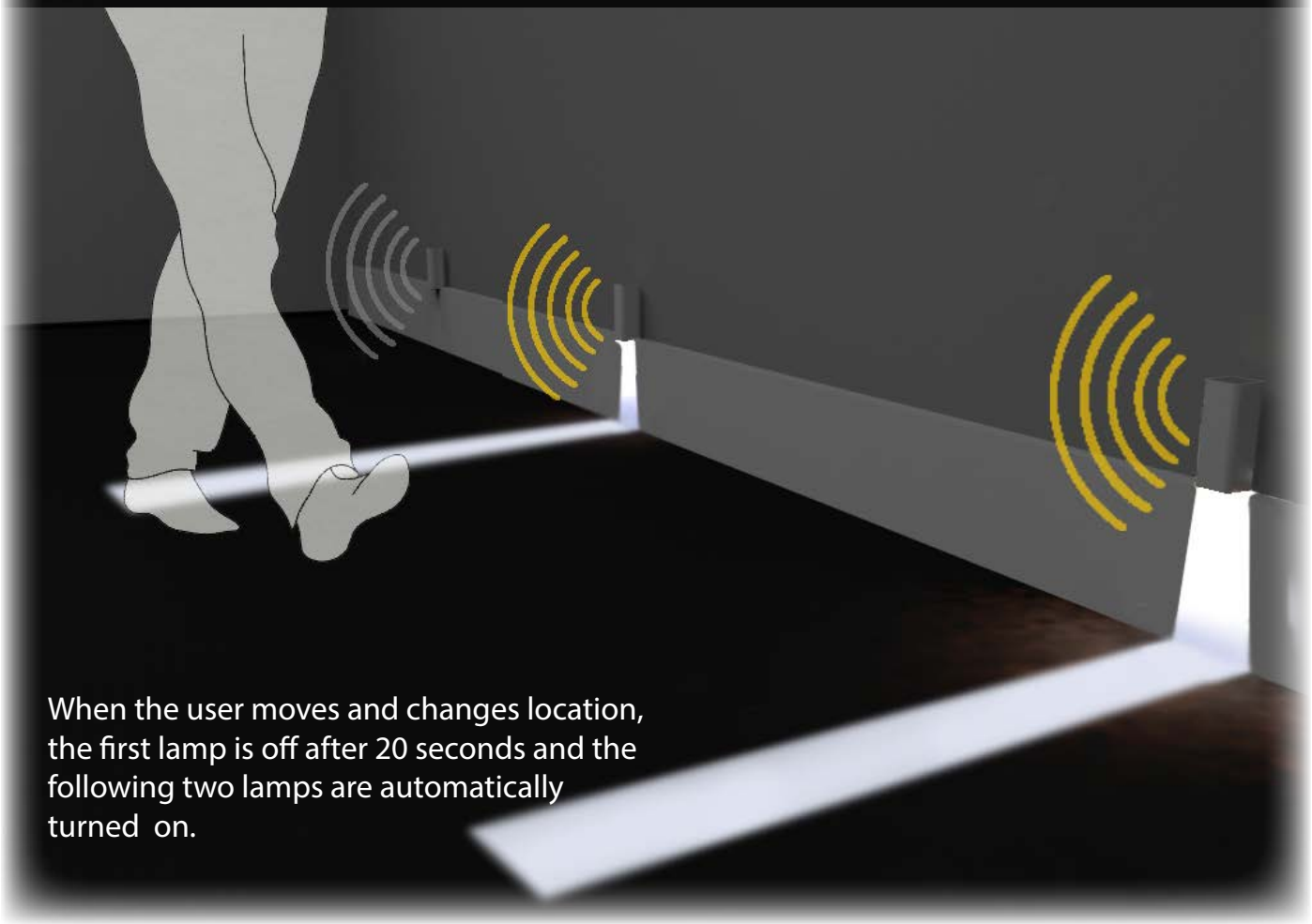
2 The LUVI lamps are already plugged into the room and they are off when there are no movement around.



3 When the user starts moving, the LUVI lights get in reaction and create light strips on the ground. These strips made of light aim to create a path to guide the user in the dark house without emitting too much light which could disturb the eyes. So, the user moves in the room in a comfortable way.



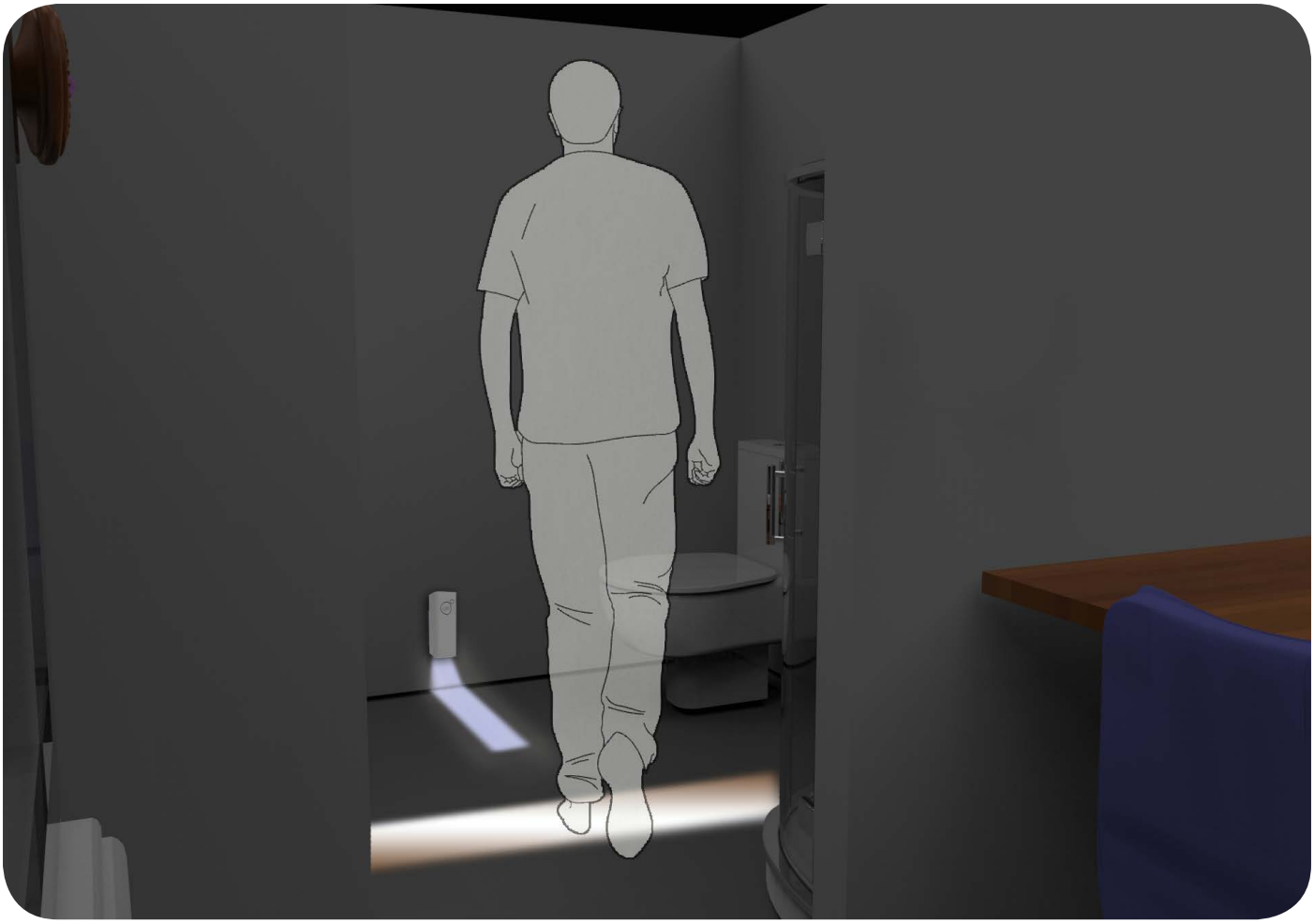
The motion sensors placed on the lamps are activated to sense the movement of the user. When a lamp detects the motion, that lamp and the following lamp are activated. In the picture, the first two lamps activated by the motion and a lamp which is still off can be observed.



When the user moves and changes location, the first lamp is off after 20 seconds and the following two lamps are automatically turned on.

4 The user arrives in the living space and the LUVI lights are placed also in this area of the house. When he first enters in the room, the first two lamps get on and the third one is ready to react.

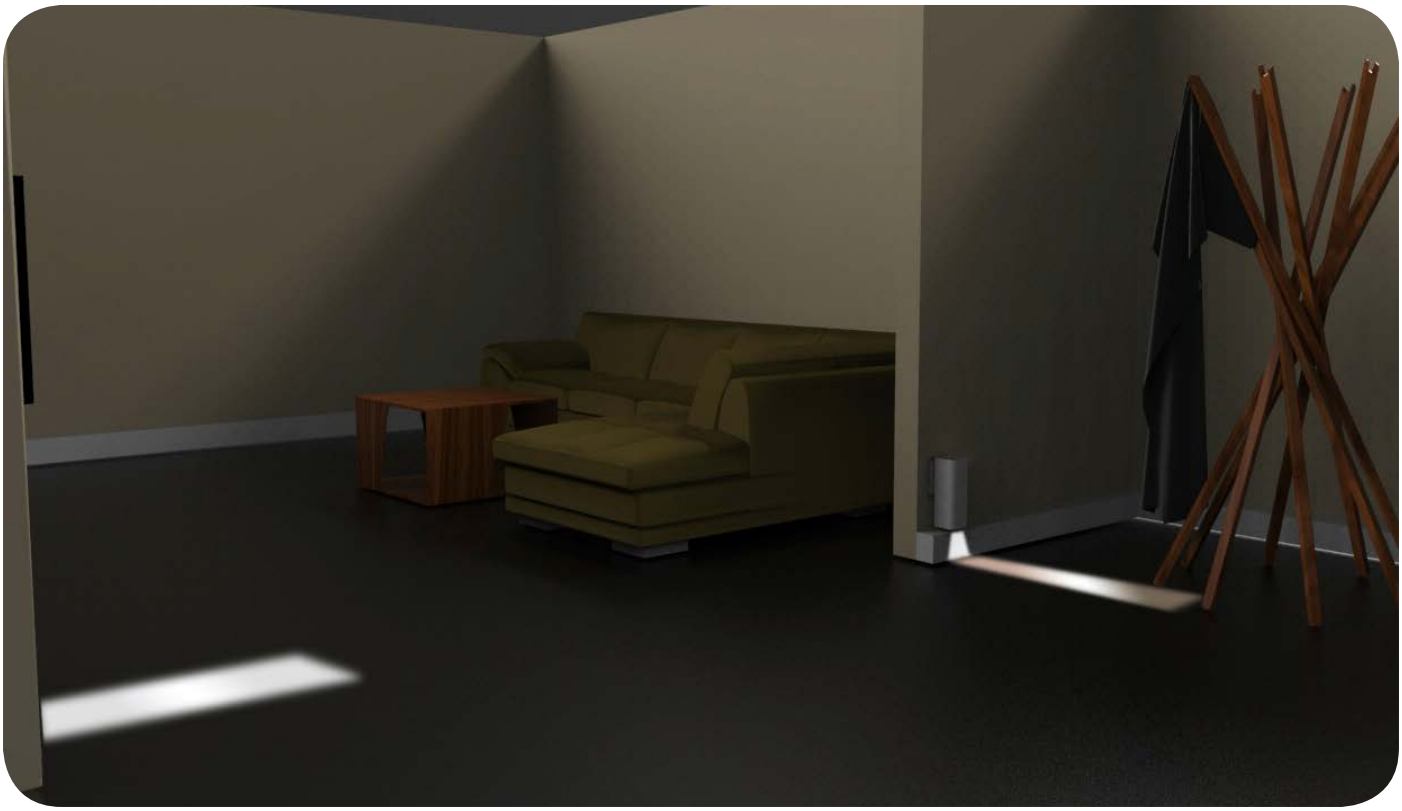
5 While the user moves in the room, the third lamp detects the motion and gets on as well.



6 In the bathroom, the LUVI lights are still present and plugged to guide theuser within the bathroom.

Here, an example of lighting layout composed by 10 LUVI lamps is shown with the look when all the lights are on in the night.

The LUVI lamps are useful also when the user is entering in the house. As it is an annoying situation to stay in the dark just after entering home, the LUVI lamps can be plugged near the entrance to detect the movement of the door and used to find the path to go to the area light switches. An examplified effect of LUVI lights for this situation can be found below:



The left side surface of the product includes a push-button switch to turn the lamps on or off individually.

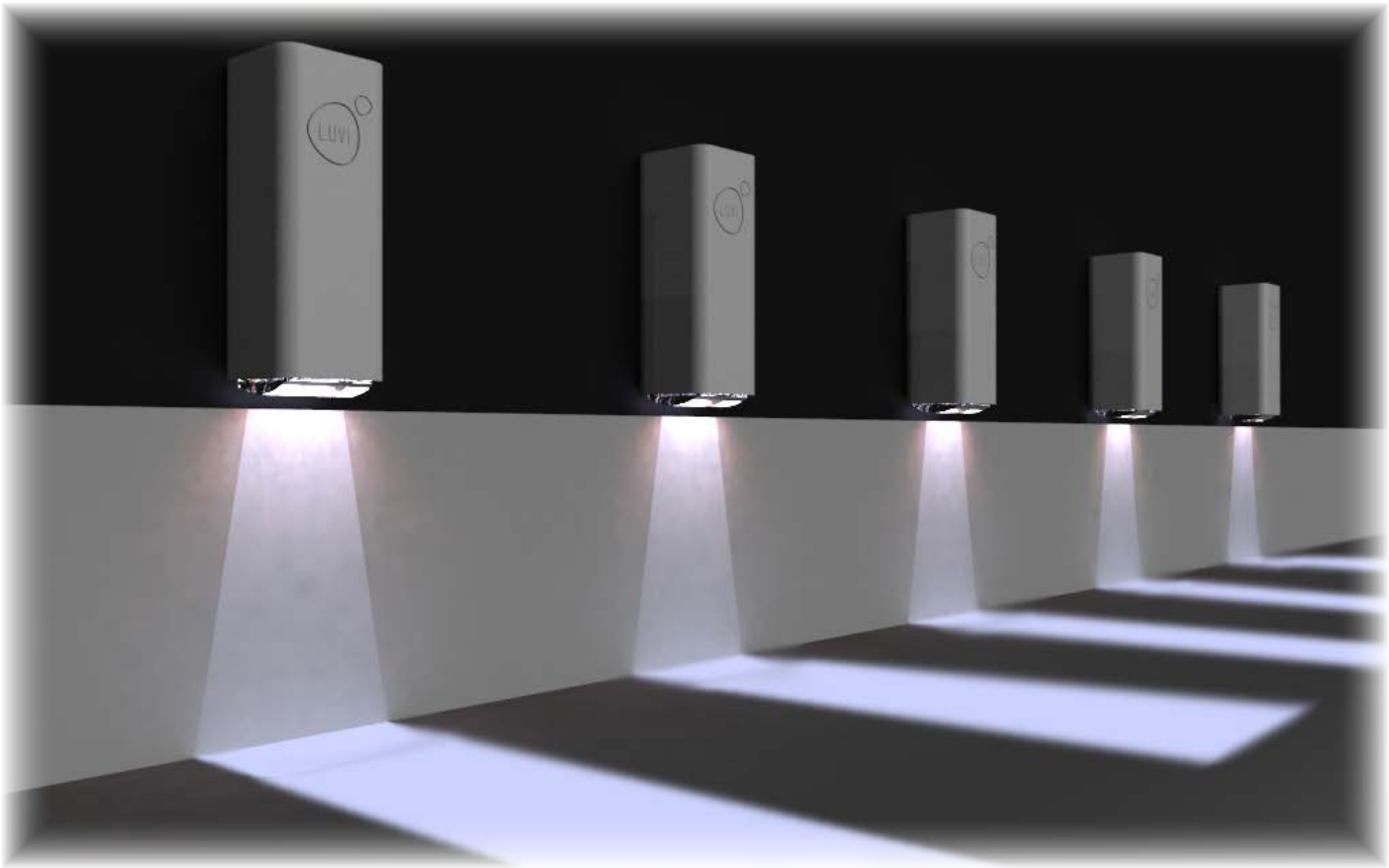
The ring light and the enlightened stand-by icon are used to indicate the state of the lamp.

The lamp can be easily turned on and off by pressing the button. The indicator light gets off when the lamp is turned off and vice-versa.

c. The Effect and the Optical Layout

The LUVI lamps are designed to create a sharp light that do not diffuse in the environment, with minimum reflections and refractions and low intensity in order to make it suitable for the night use. As the lamp is used as a night light it's been considered to create a light effect that would not disturb the eye of the user, as well as the other people living in the house.

For this, the aim of the project was to create light strips that are as sharp and even as possible, in order to create a path to guide the user in the house during night time. So, the lamps are mounted at a low level -near the ground- on the wall, and the sharp light guidelines are projected on the ground. The final effect of the lamps can be observed below.



However, light is naturally tended to diffuse in the space as beams. To obtain this desired effect the light source and the optical methods had to be studied well. As there are a variety of solutions to collimate the light beams, most of them are not suitable for domestic uses because of the 'blue hazard' and other negative effects, the size of the systems, need of big empty spaces etc. One of these unsuitable solutions was to use a laser. Laser is the best way to create lght lines, while after a while, it creates an unwanted effect for the eye health. The projection was another unsuitable solution because of the need of avoidance of obstructing objects in the house.

As the final solution, an optical settlement has been created to create exactly the effect seen in the picture above.

The Optical Layout

The ABS Shell

The Light Source
(LED strip)

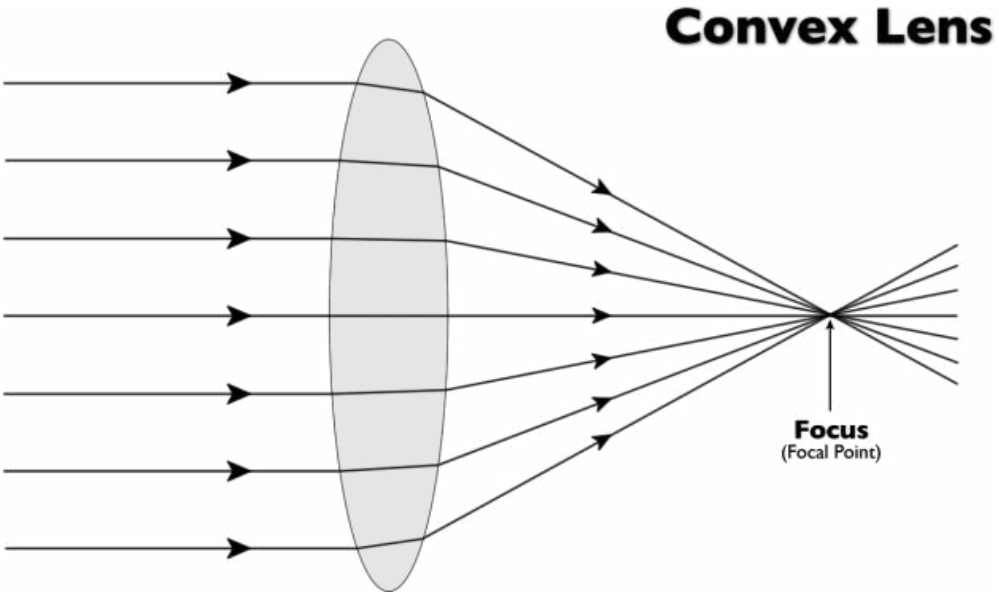
The Fresnel Lense

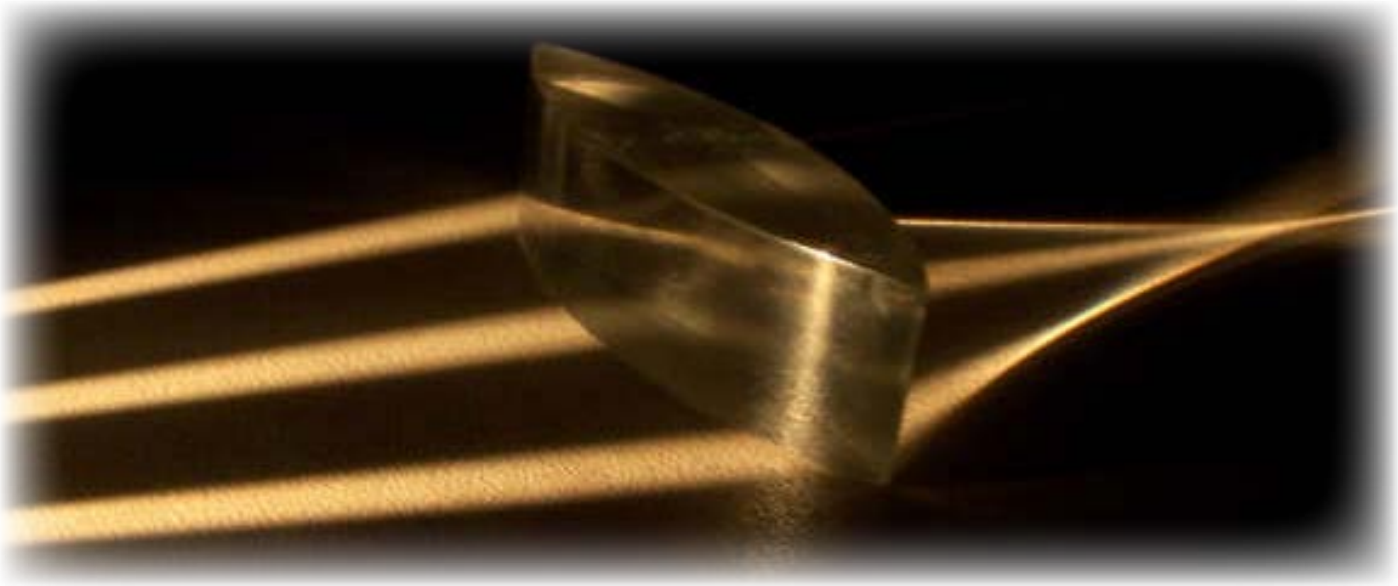
The Removable
ABS Frame

The Optical Lense

To obtain the sharp and precise linear effect with light, the selection of the right optical lense was one of the most important steps to make decisions.

As known by the basic 'Optics' knowledge, the convex lenses are naturally able to collimate the light beams at a single point. So first, the convex lenses have been studied. A basic schema of a convex lense can be found below.

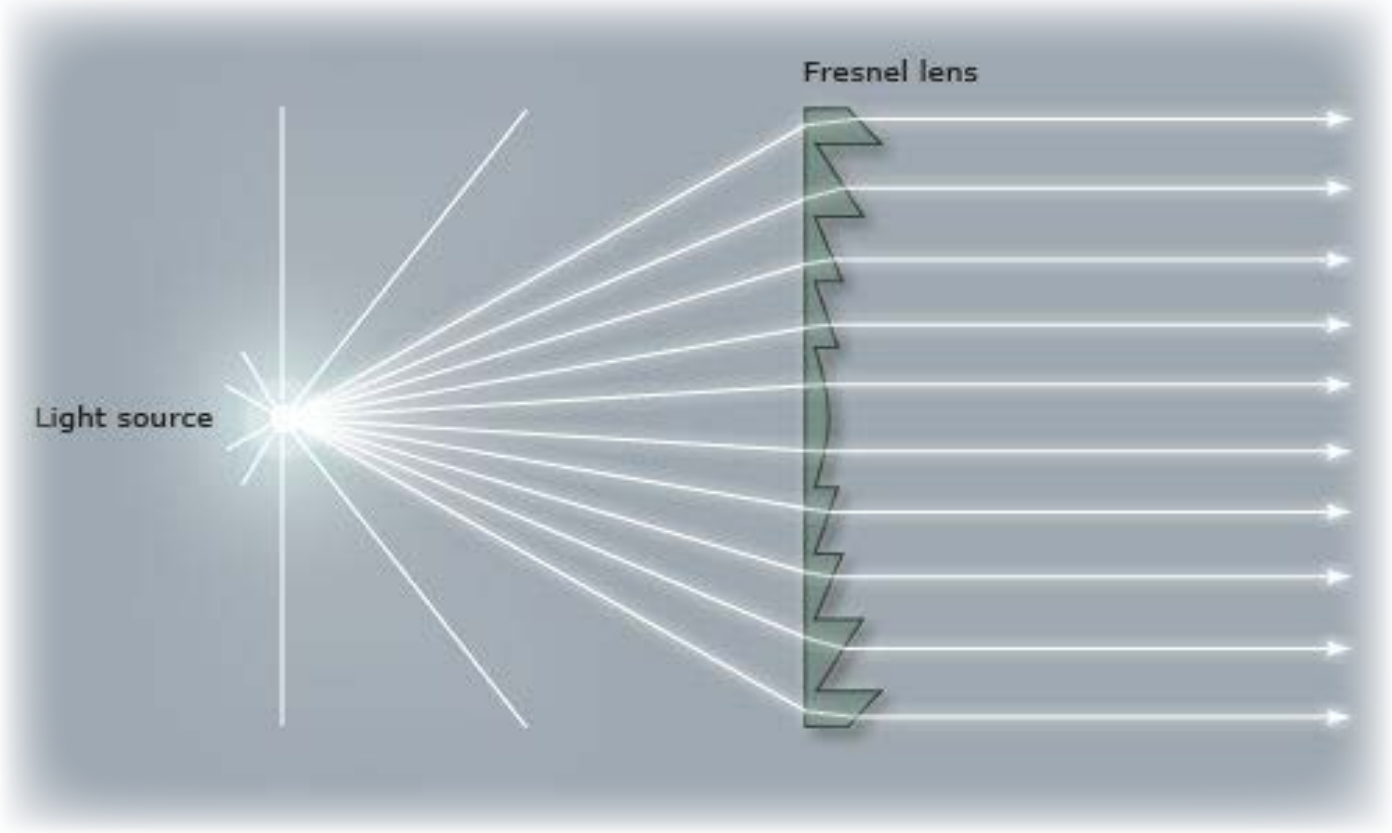




However, the focal distance of these lenses are usually high and as a design choice, the designed lamp needed to be as small and compact as possible.

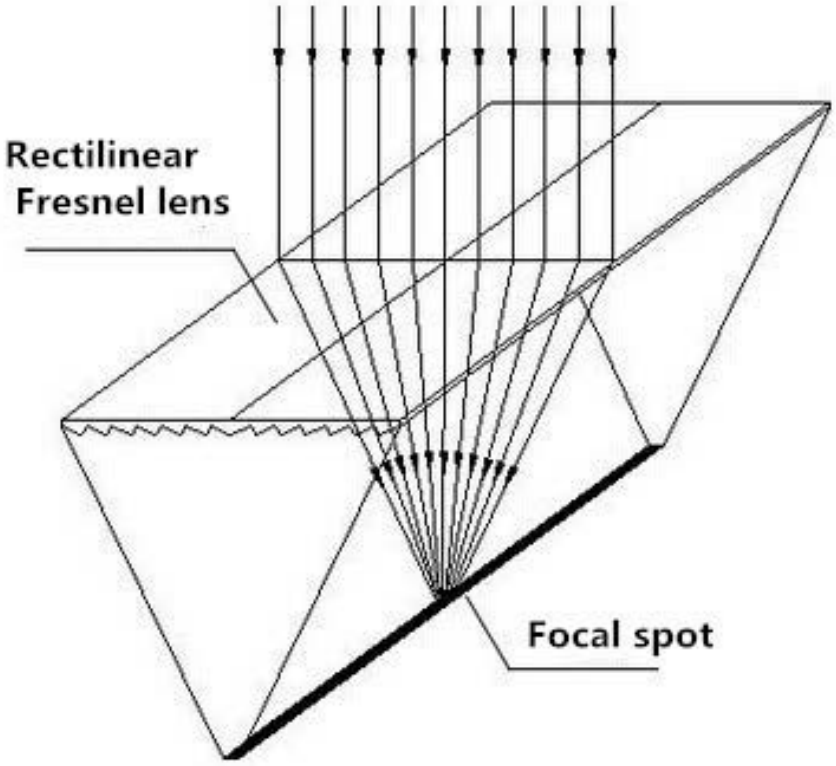
Additionally, the level of collmation of these lenses is very sensitive to the position of the light source. To obtain the desired effect, the light source has to be fixed to the exact point at the focal distance and no changes - even if the change of location is very small - are tolerated.

So, there was a need of a better solution to collimate the light as a single line of light on the ground. After a research, the selection of the lense to be used has been realized as a 'Fresnel Lense'. The effect of the fresnel lenses is shown as pictures.

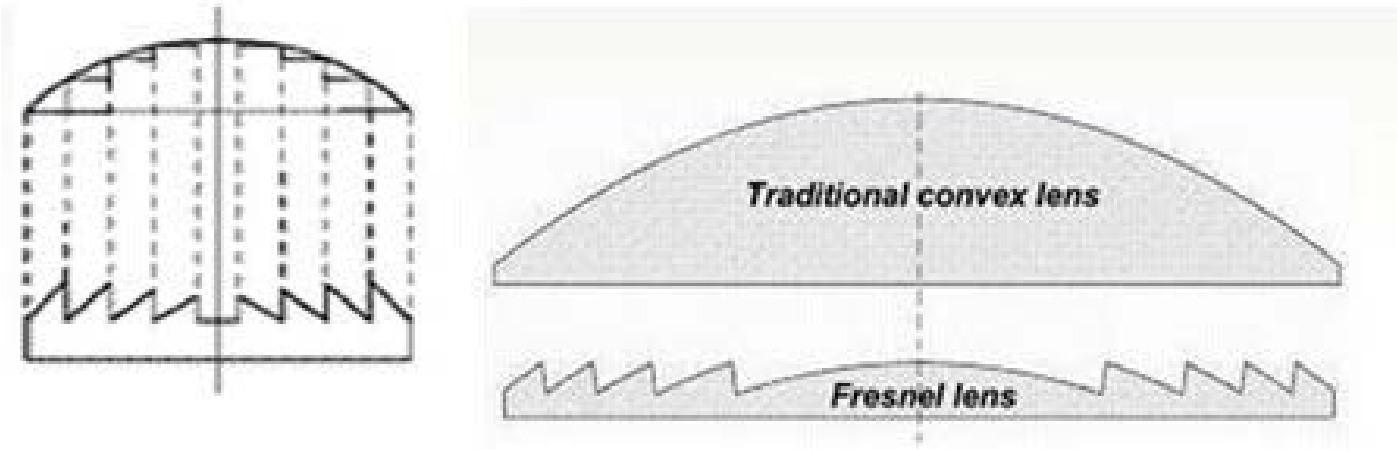


A fresnel lense acts as a collimating convex lense and collects the light beams at a single point. In this example, the light source is a single point diffusing the light; while the light beams coinciding with the surface of the lens are changing direction with a lower angle.

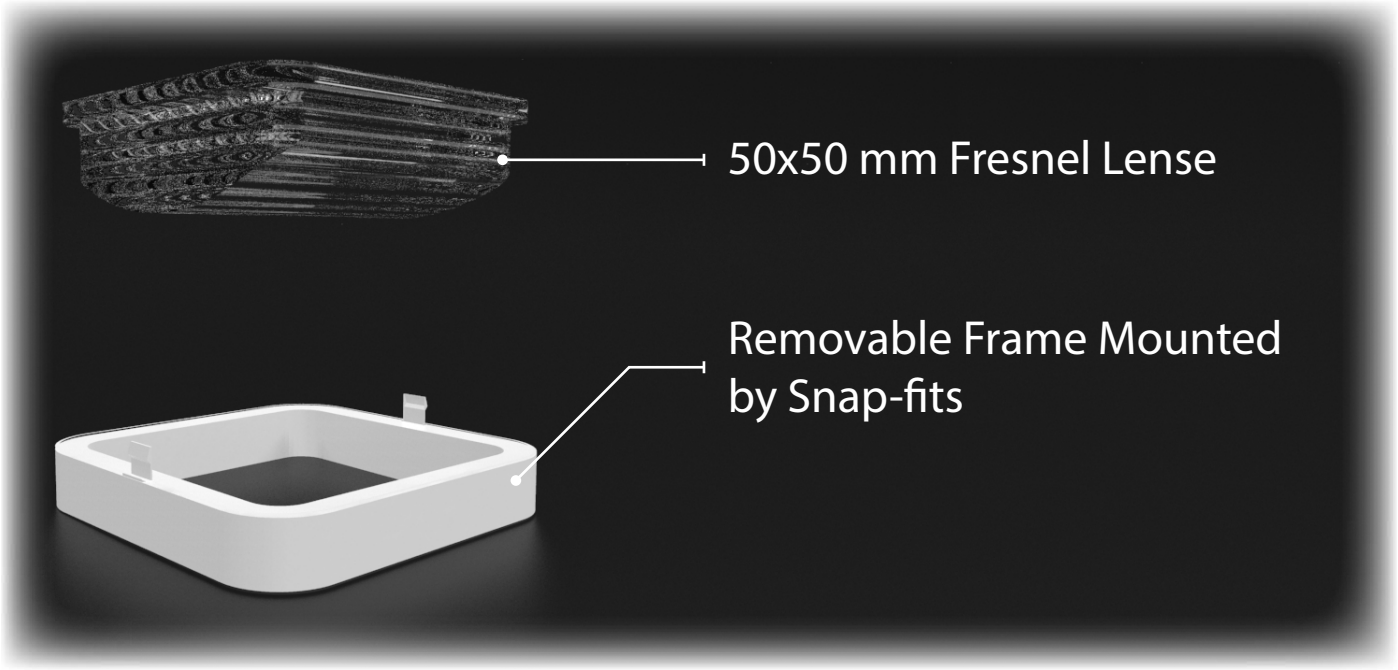
The fresnel lense's effect in daylight can be observed above. The diffused sunlight becomes a very precise line, even if the light is not placed exactly at the focal point. If the light source is placed at the focal point, the precision of the light beam would be greater.



As seen in the picture above, the light beams arriving on the lense surface perpendicularly, are collected at a single point. So, a light source having a larger area creates a beam projected on the ground as an image of light. The width and the precision of the projected image depends mainly on the distance between the lense and the light source, while the size of the lense and the light source, the type of light and the intensity of light are other factors influencing the refraction and the projection quality.



The main difference between the fresnel lense and the regular collimating lense is the thickness. The fresnel lense's special shape allows more efficiency with a lower size. Additionally, this special shape reduces the sensitivity of projection quality to the optical placement (focal distance).



The fresnel lense used in LUVI lamps are designed as two layers in order to fit in the ABS frame.The used lense has the dimensions of 50x50 mm which is the smallest size that can provide the linear lighting effect.

The lense module can be easily removed and remounted using the snap-fits in order to provide ease in maintenance.

By removing this bottom part, the light source, the lense and the electronics can be reached easily in case of a need of service.

Selection of the Light Source

The light source used in LUVI lamps is LED. The type of LED bulb is a 'High Power LED' in order to ensure the sharpness of the emitted light.

The High Power LEDs include a convex lense that collimates the light beams at a certain level. As it's not sufficient to give the desired effect, it will be helpful to keep the light strips precise without the need of high sensitivity during the production and usage steps.

Advantages Of Using Led As The Light Source

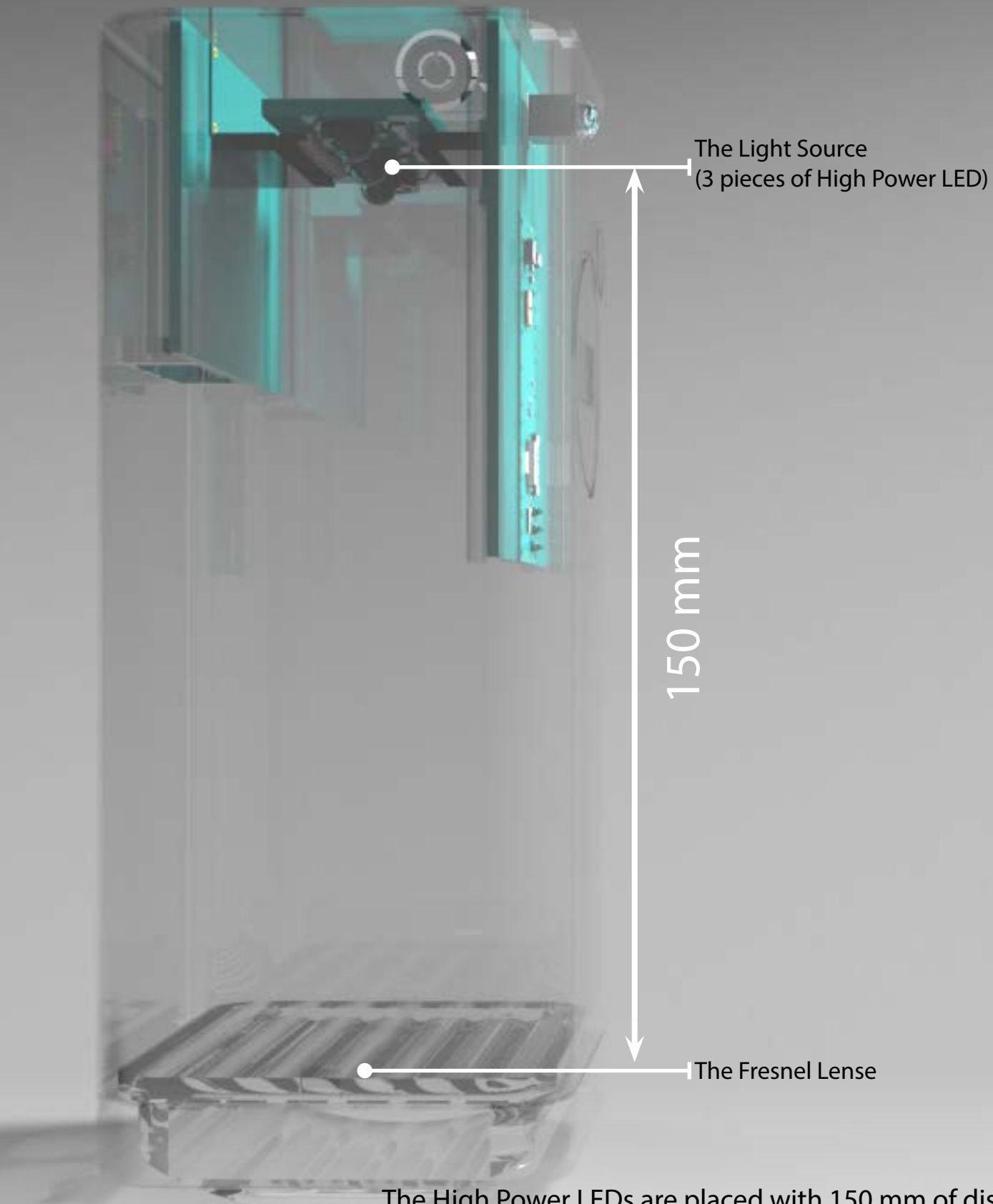
- Energy Efficiency: For the customers this would be a positive reason to chose LUVI lamps to buy.
- Design Flexibility: The small size and ease in adjustments of the emitted light makes LEDs advantageous for this application.
- Durable Quality: This feature reduces the need of maintenance and repair. The durability avoids the need of sensitive use.
- Long Life: Again, this feature reduces the need of maintenance and repair. The user can use the lamps for a long time without changing the bulb.
- Eco-friendliness: Because we care about the Earth.

Advantages Of Using High Power LED

The High Power LEDs' main advantage for this application is that these components is basically a light source covered with a collimating lense. As the first aim of the designed optical system is to collect/collimate the light beams as much as possible in order to obtain the light strips projected on the ground.

As the Fresnel Lense is used to collimate the light beams efficiently, it has to be guaranteed by the used lighting component. By the use of this type of LED, the creation of the light strips is ensured and the quality of the strips is not very sensitive to the position - while the LEDs are placed at the focal point of the lense for the best result - .

The placement of the Optical Components



The High Power LEDs are placed with 150 mm of distance with the Fresnel Lense. This distance is the exact focal point of the 50x50 mm lense, and necessary to create the precise light strips on the ground. This distance is one of the main issues defining the size of the whole object.

The Sensors

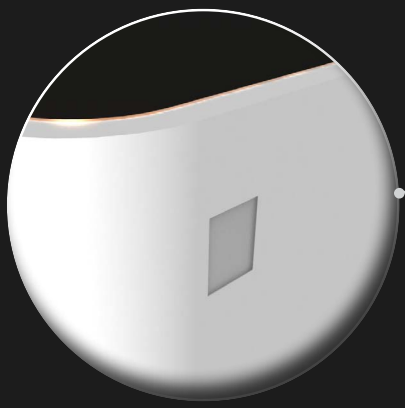
1. The PIR Motion Sensor

A PIR Motion Sensor is placed on the top front part of the ABS shell. This sensor detects the movement of the user and activates the lights accordingly.

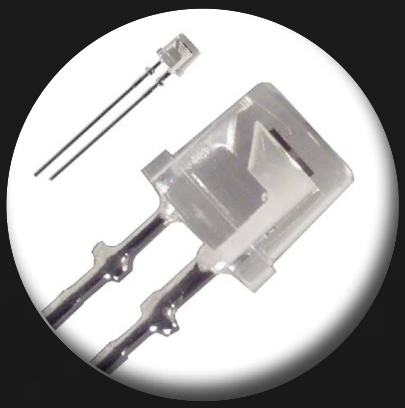
The HC- SR501 motion sensor choosen for this application is able to detect the human motions within 100 degrees.

The motion sensor is used to offer a more natural way of interaction to the user. By the use of this sensor, the user can activate the light easily, without applying an extra effort.

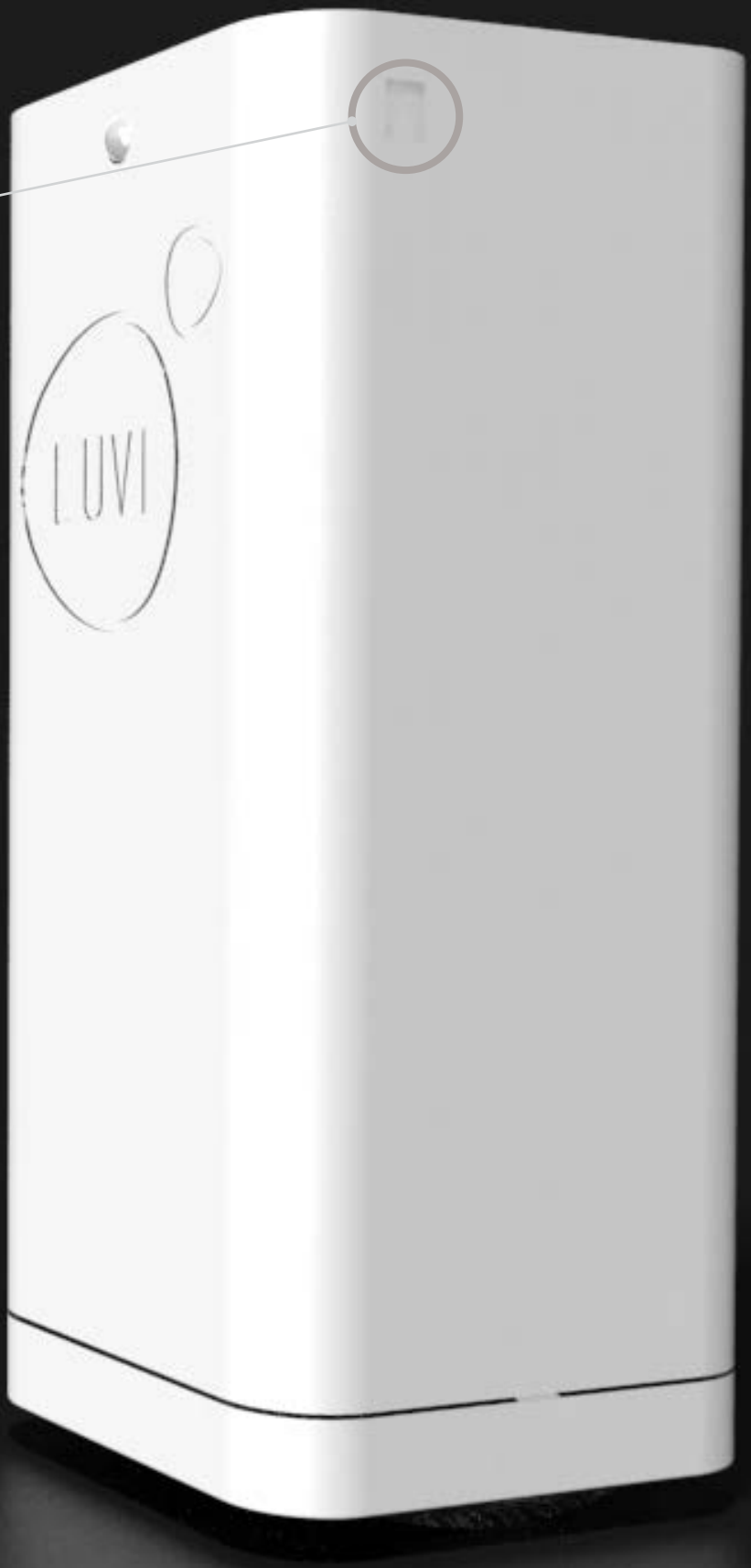
2. The Ambient Light Sensor



A Photo-Diode is placed on the left top part of the ABS shell, in order to detect the daylight or other ambient lights in the space.

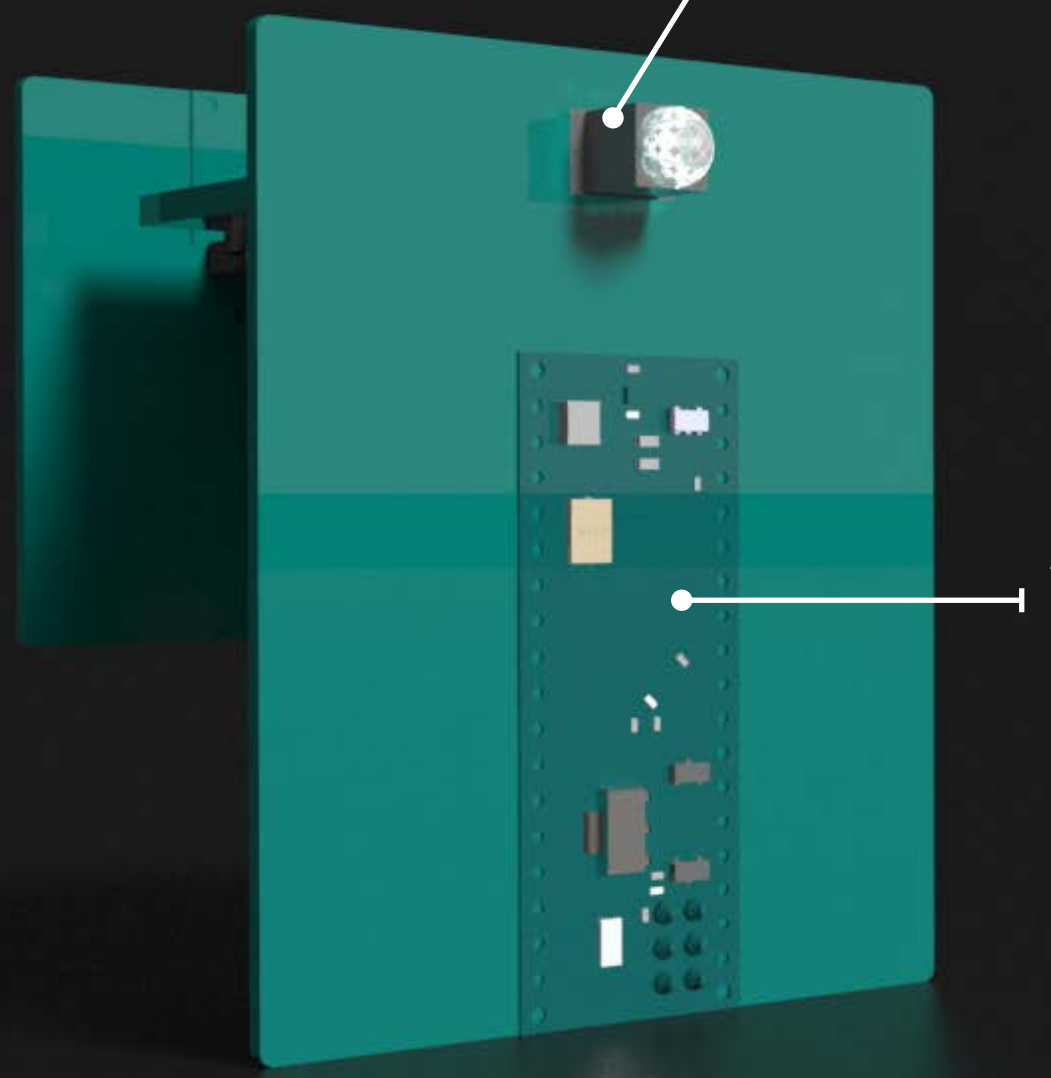


The Photo-diode sensor choosen for this application is Osram SFH 203 P.



The use of an ambient light sensor (a photo-diode) aims to avoid the lamps to be turned on when there is sunlight or an ambient light in the room. This provides energy saving, as well as being eco-friendly.

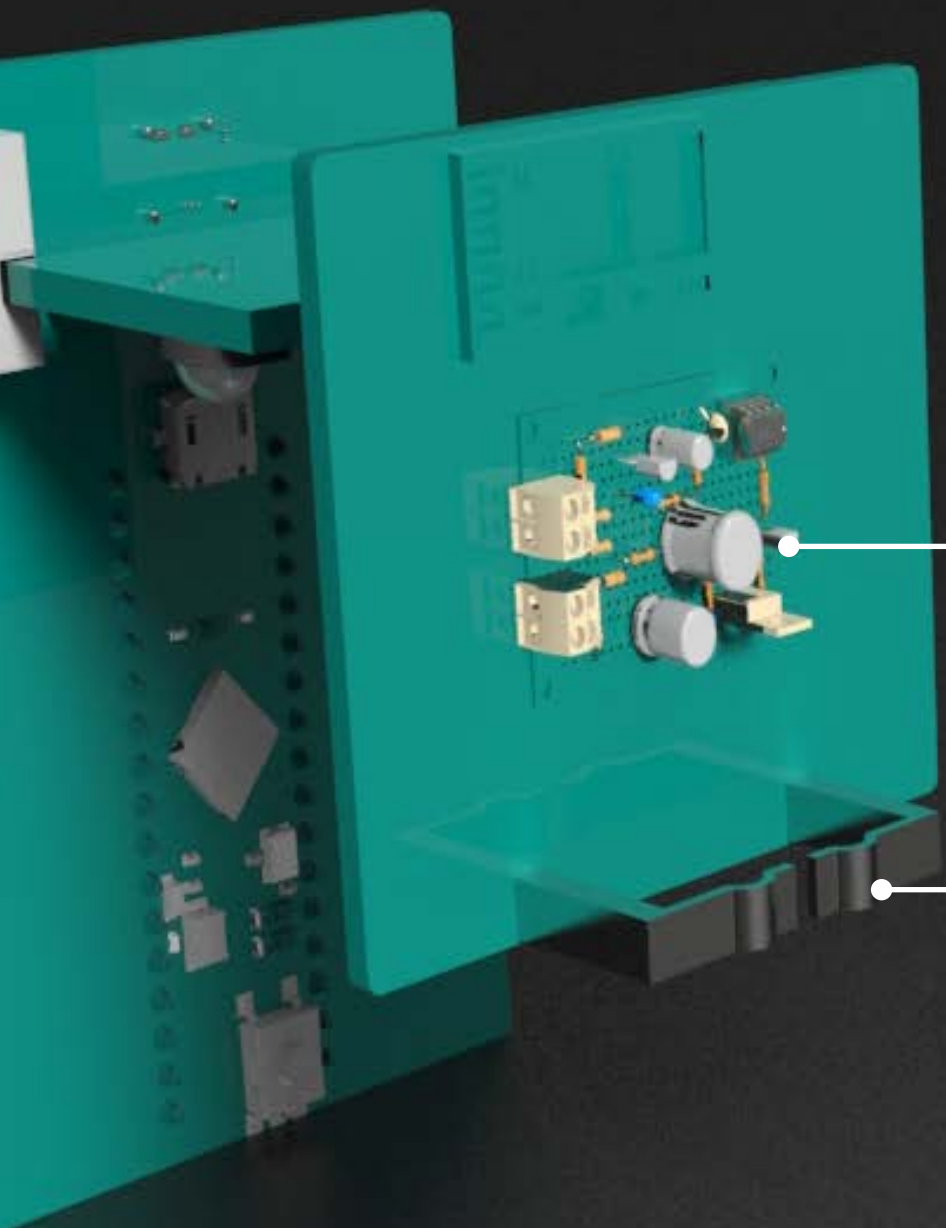
The Electronics: Printed Circuitry Structure (Front Side)



The PIR Motion Sensor is placed on the front side of the circuit to be on the top part of the lamp in order to easily detect the motion of the user.

The front side includes also the PCB (for example 'Trinket Pro').

The Electronics: Printed Circuitry Structure (Back Side)



The second part of the PCB is placed on the back surface.

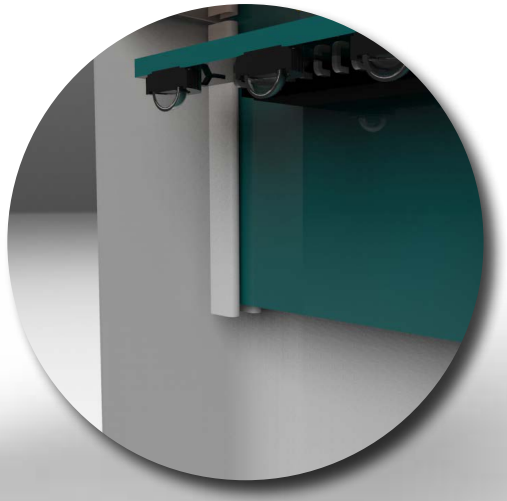
The electricity connectors providing the power of the lamp are placed on the back side as well.

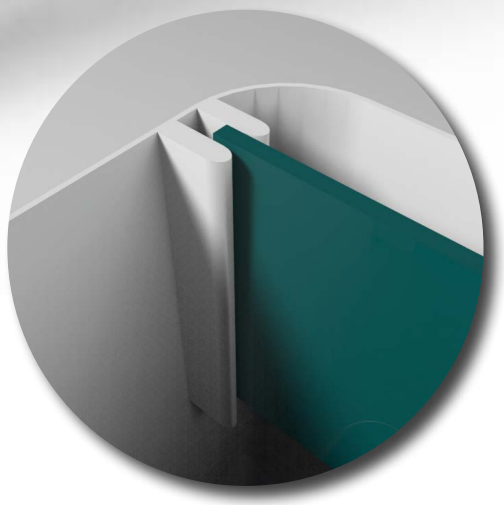
The Electronics: Printed Circuitry Structure (Middle Part)

In the middle of the two vertical circuits, a horizontal circuit is mounted in order to contain the High Power LEDs. This part is linked to the front and back sides through connectors to receive the electricity power and the sensor data.

The Electronics: Printed Circuitry Structure

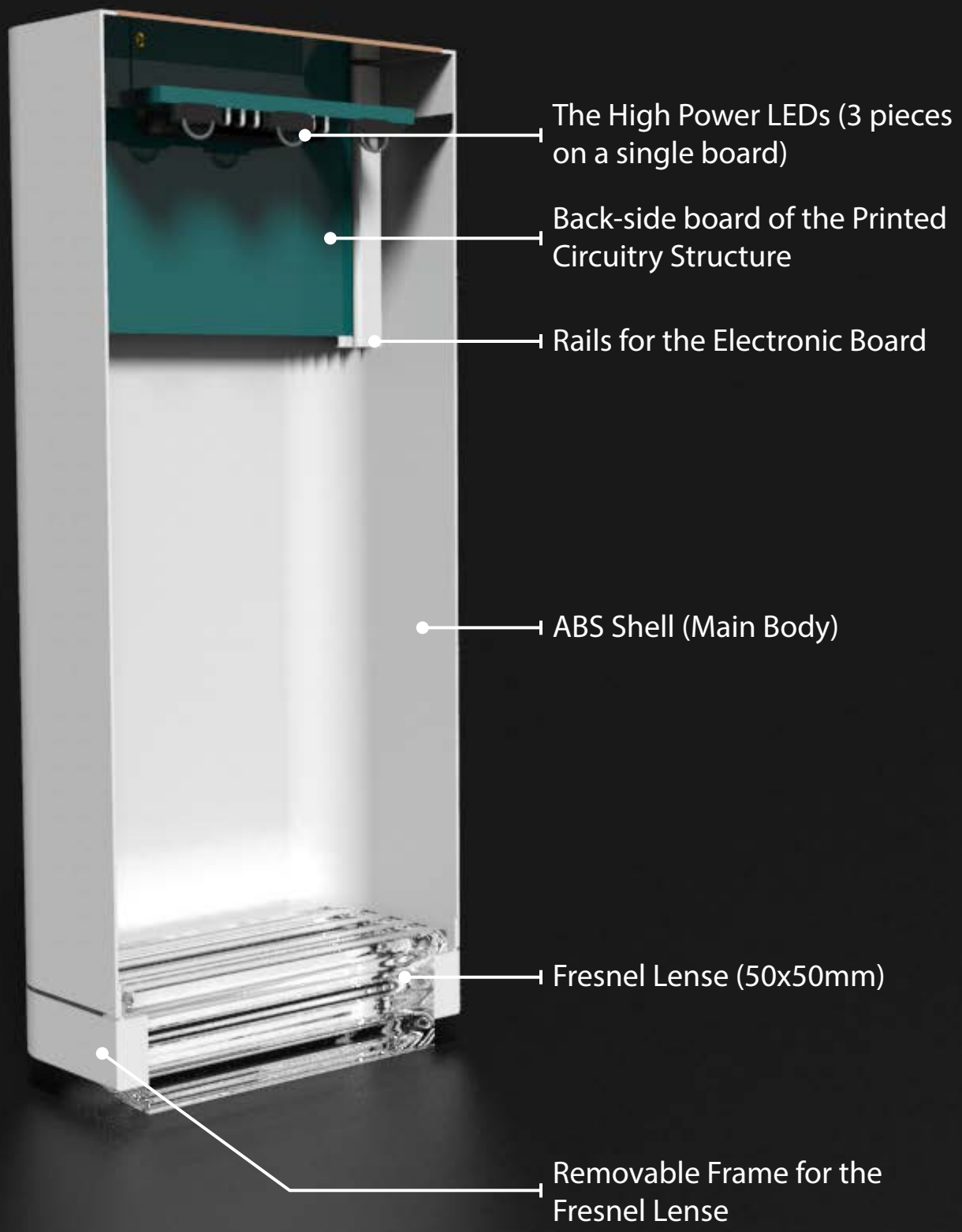
The printed circuitry system is placed into the ABS shell through the internal rails. After placing the cards inside, the cards are fixed by a glue that doesn't affect the material quality. The view of the card inside the shell and the rail details can be observed below.



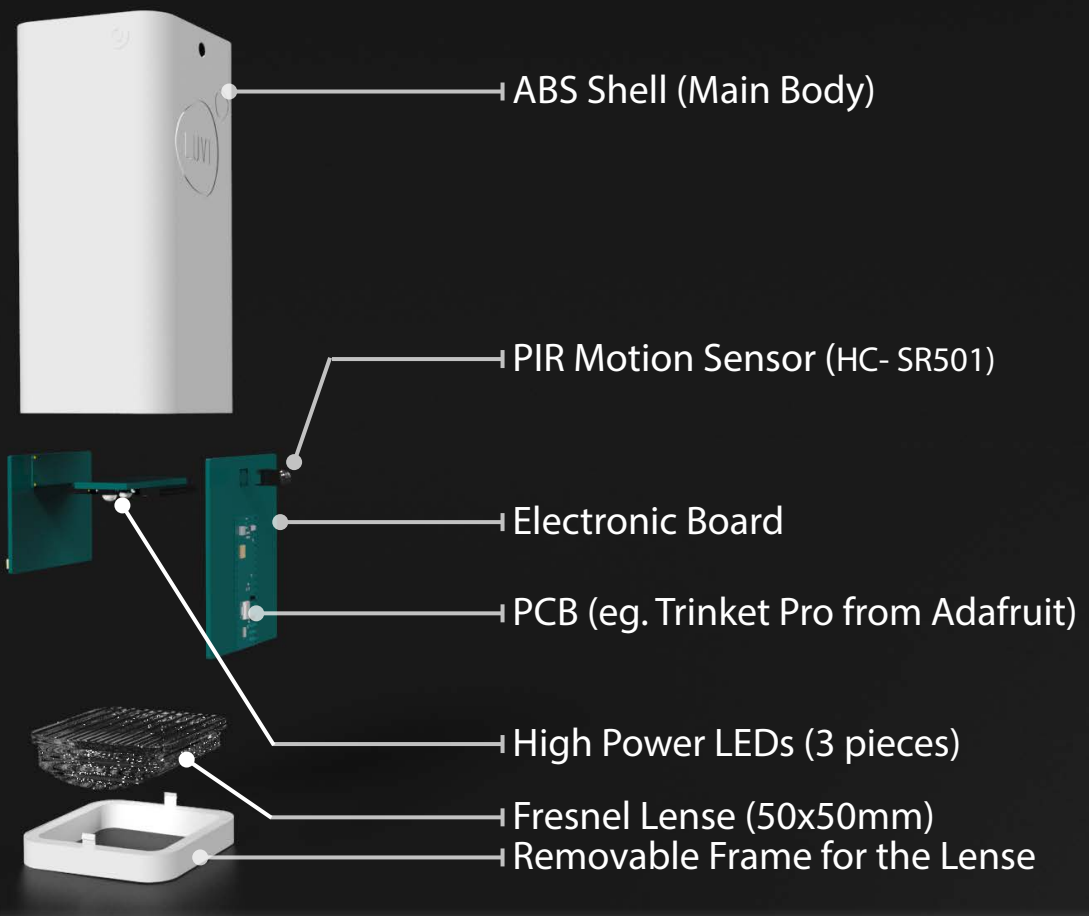


The rails are produced as a single piece through injection molding.

Sectional Perspective View

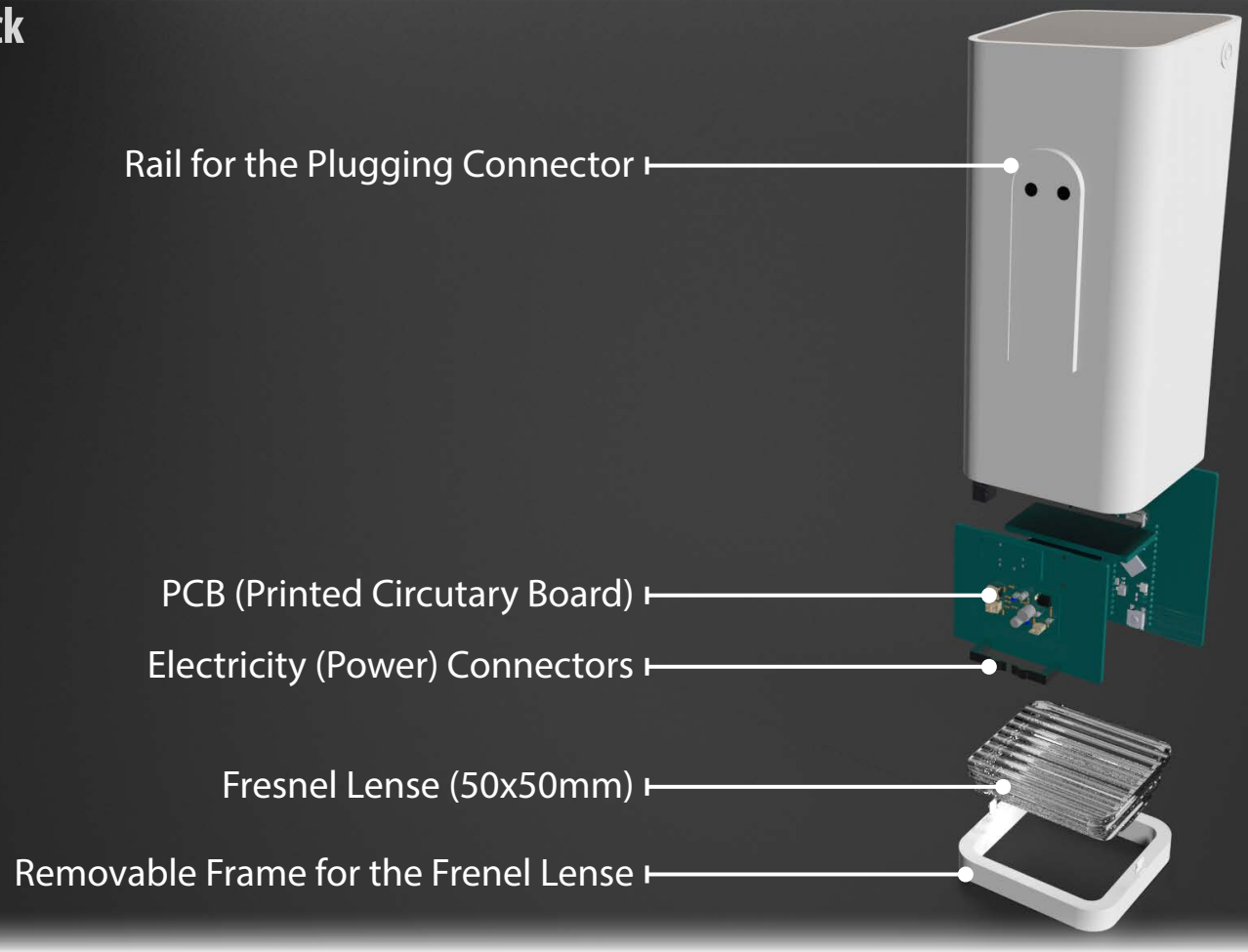


Exploded Views



Front

Back



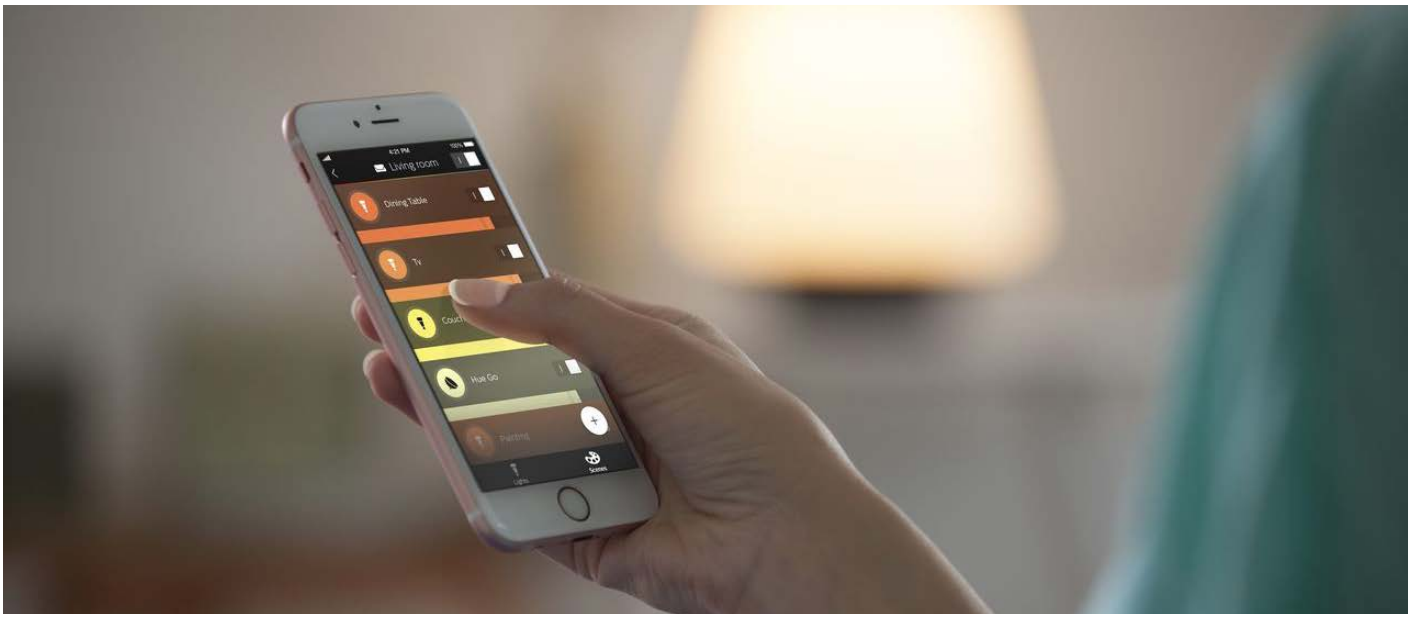
Concept 2: Create the Atmosphere

Benchmark Study: Philips Hue

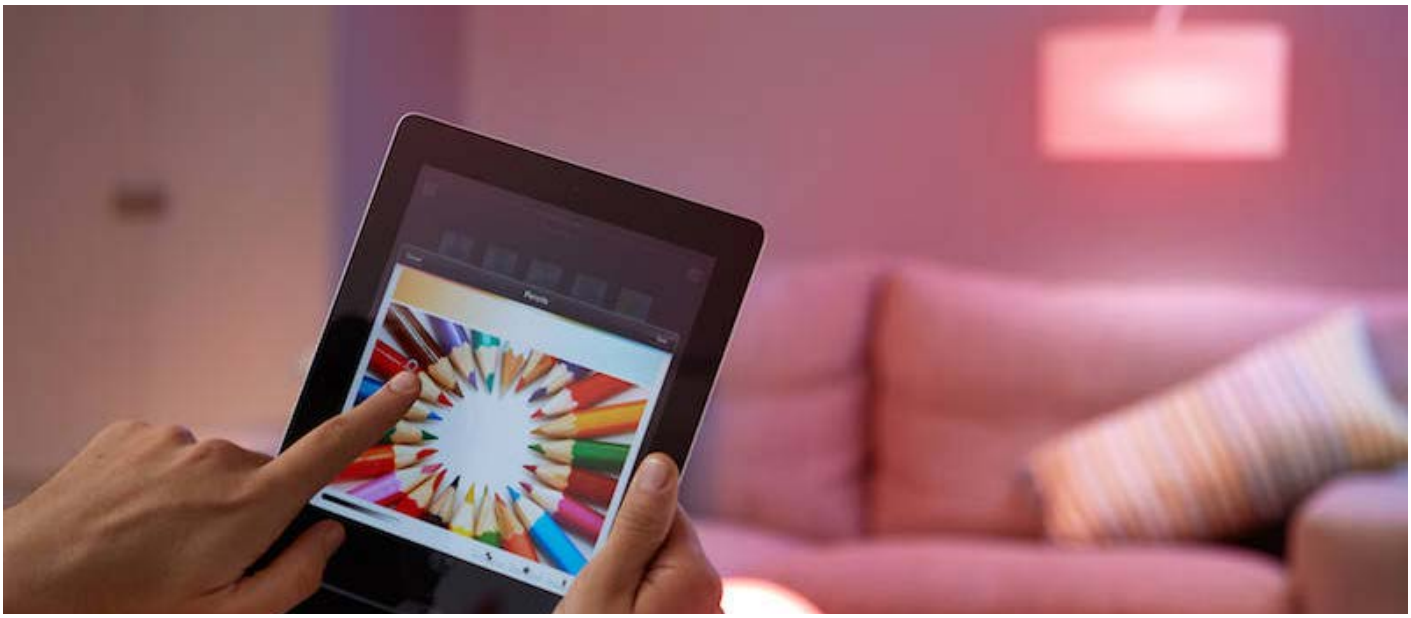
Hue is the new LED light bulb of Philips that allows the customers to personalize their lighting environment. The LED technology allows the user to adjust the color and intensity of individual bulbs for custom lighting.

Philips Hue offers the possibility to control the lights of the whole house, even the garden simply and remotely. By using Hue, different lamps can be set in different colors and by mixing the light colors, a special environment can be created easily. Some modes of Philips Hue are based on the useful effects of light such as focusing, waking up, sleeping or reading. The aim of the product is to provide entertainmental lighting that has infinitely wide options, beside lighting the enviroment functionally.

Benchmark Analysis: Philips Hue



The Hue light bulbs are controlled through a mobile application. The application includes the setting of RGB color codes, default light modes such as for reading, focusing, sleeping etc. and the option of setting the light color by using a photo. The photo is simply uploaded in the app and the light color of the lamps can be chosen from the uploaded photo. Philips has also launched a controller called 'Tap' in which a number of lighting modes can be uploaded and simply changed by using the three buttons. However the app is the main controller of the Hue lamps and includes a variety of optionalities.

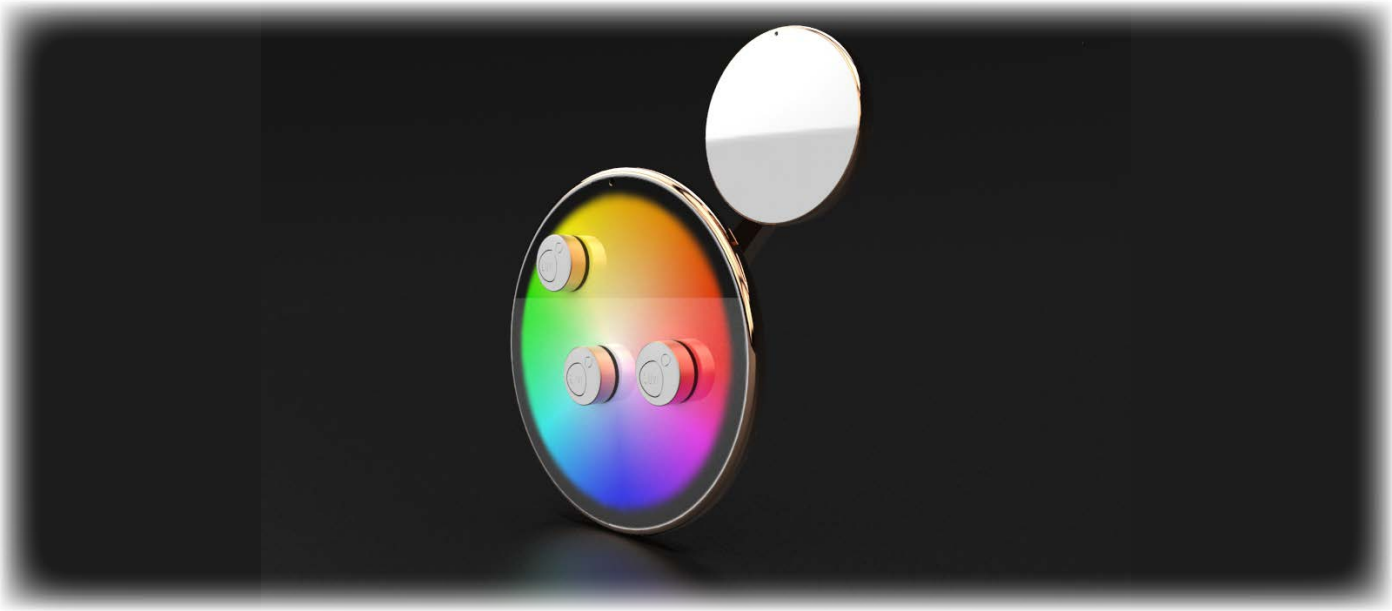


The control panel of LUVI lights is created by the inspiration of Philips Hue, but with a more physical way of interaction.

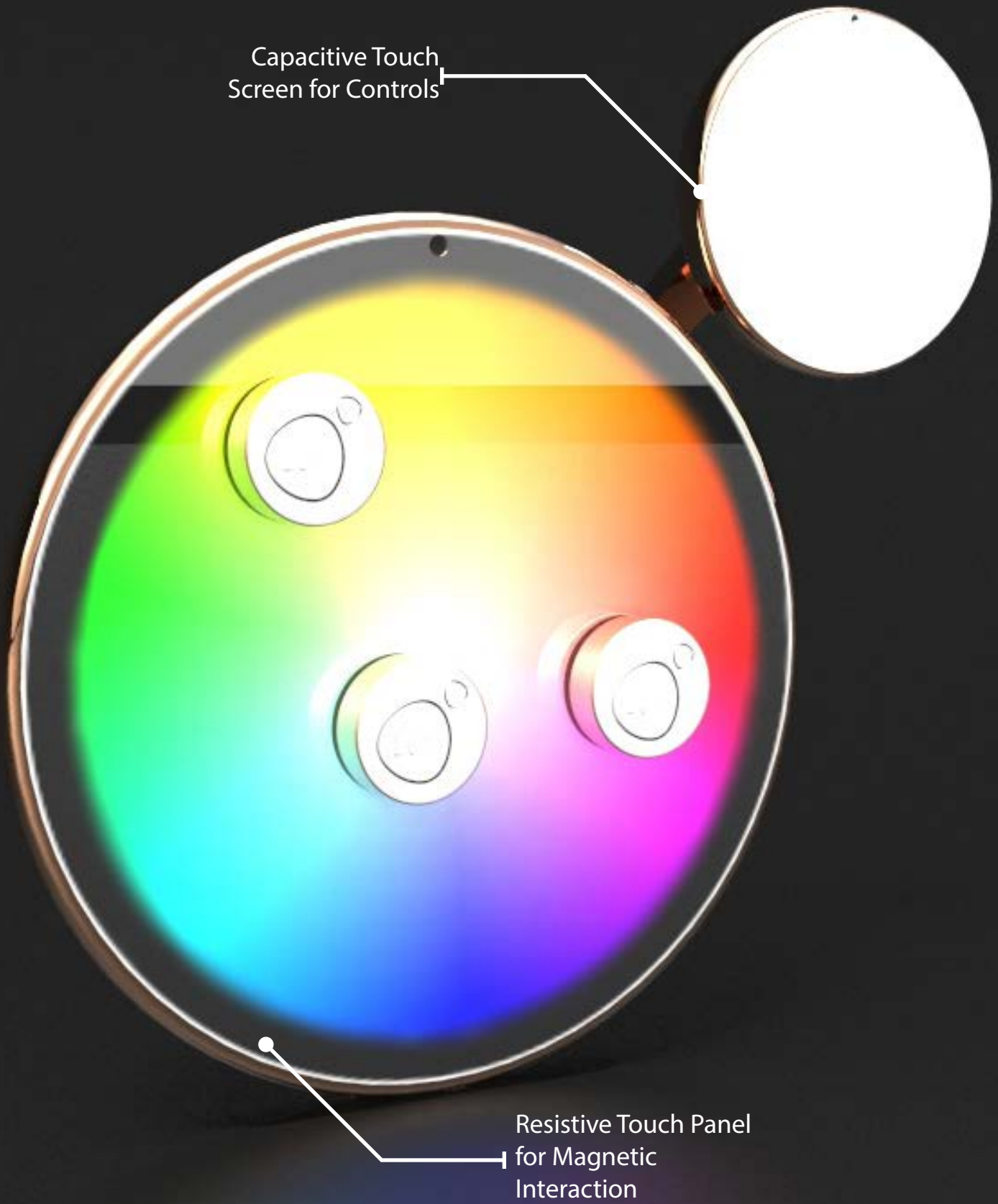
This second concept needs an additional product to be bought which is the control panel of LUVI. The control panel is used for entertainmental applications and sold separately to offer the user the possibility of making decisions depending on their usage area and their budget.

The use of the control panel requires at least three LUVI lamps and it's sold with three magnet controllers as default. The number of lamps and the magnets can be increased later.

+



The Wall-Mounted Controller



The Magnetic Touch Panel

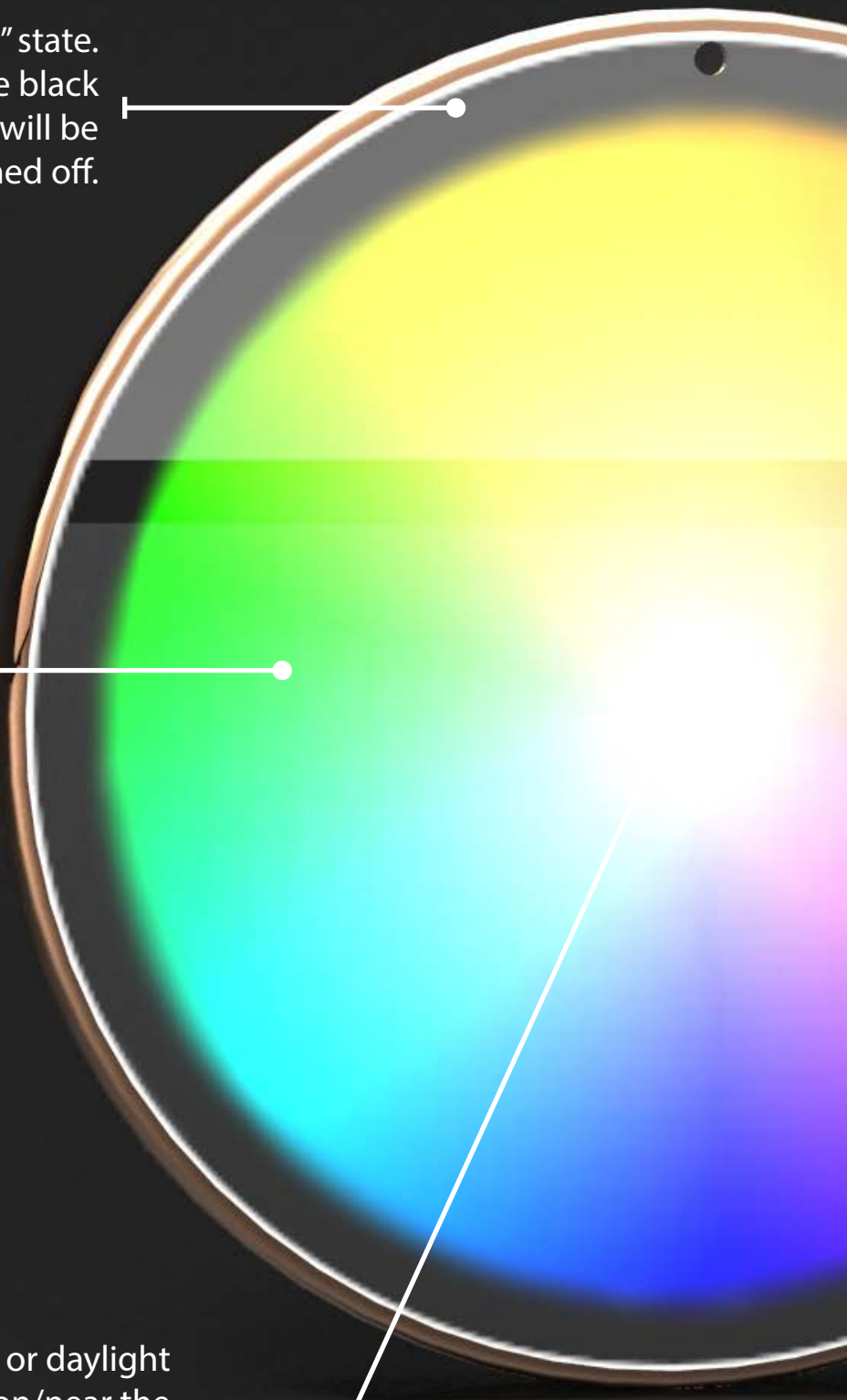
The bigger screen is a touch panel that can be used by the magnets given in the package when a lamp is bought. Each magnet symbolizes a lamp and the location of the magnets determines the color of each lamp.

This aims to create an athmosphere by mixing the selected colors.

Magnetic Touch Panel: Color Scale

The black part symbolizes the “off” state. When a magnet is placed on the black area, the attached lamp will be turned off.

The color scale is used to adjust the colors of the lights. The color code of the area on which the magnet is placed, is the color coding of the light of the attached lamp.



The light can be set to be white or daylight color, by placing the magnets on/near the center which is the white part of the color scale.

Touch Screen

The interface consists of
4 basic icons:

Camera Mode

Color Scale Mode

Gallery

Standby/Power

Camera Mode

The mode can be selected simply by touching the camera icon.

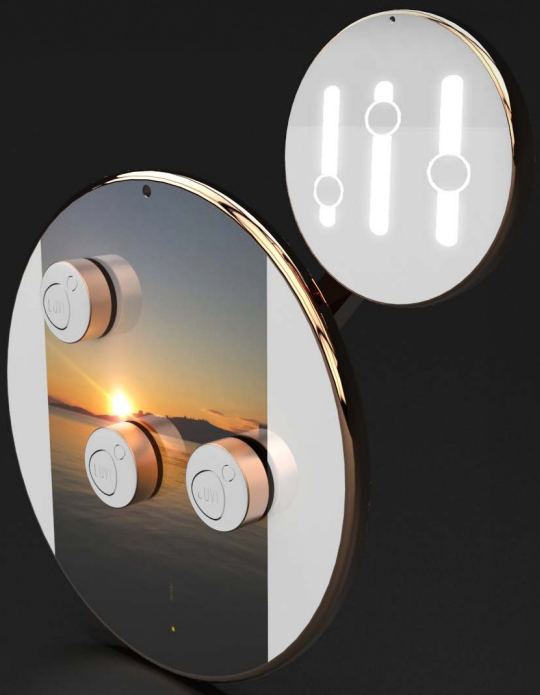
Once the mode is selected, the camera icon will be bigger in the middle and the other icons will disappear. A green LED will be on, in order to guide the user through the camera.

The user has to show an image to the camera at this point. This image can be a printed photo as well as a digital one shown by the phone screen.

When the image is recognized by the camera it will be shown on the magnetic touch panel ready for adjusting light.

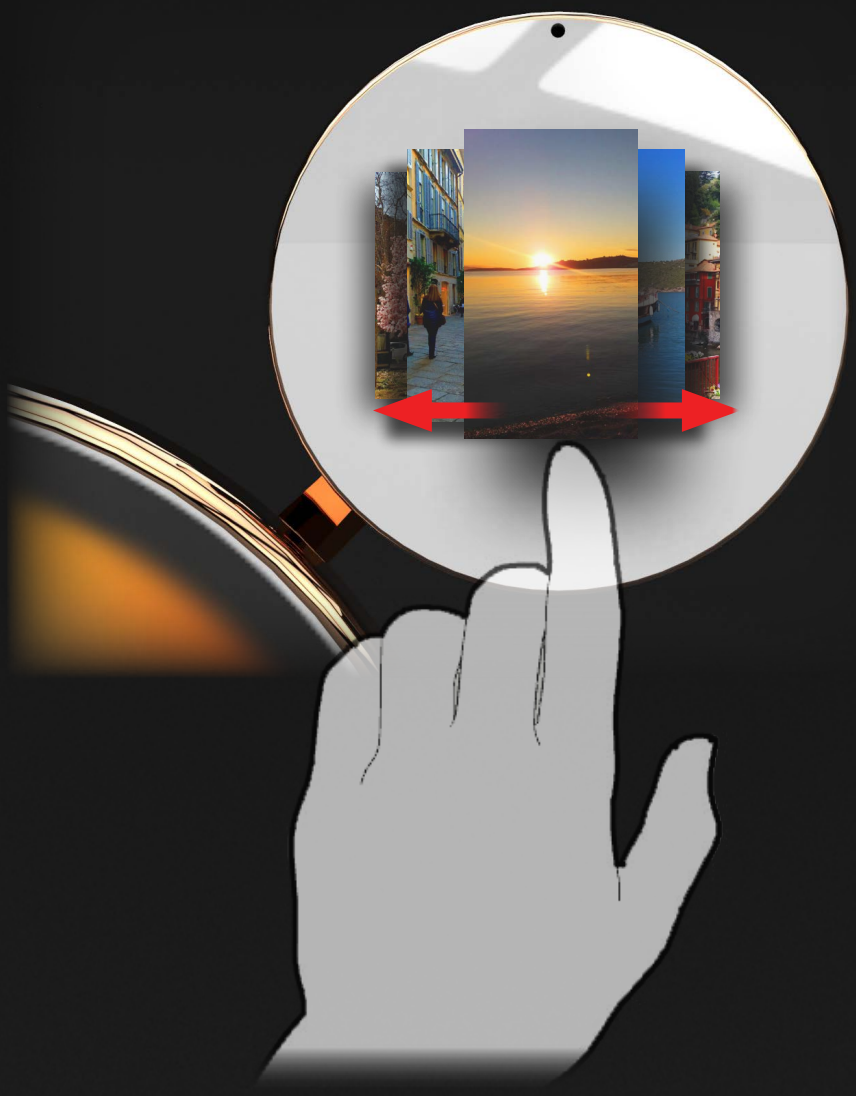
The light color is set by the magnets placed onto the picture on the touch panel. The color code contacted by the magnets would be the same with the color of the connected light.

The opacity, the saturation and the scale of the image can be easily set by using the levels shown on the touch screen.



To change mode or turn the device off, the user can go back to the start screen by touching this small “home” icon.

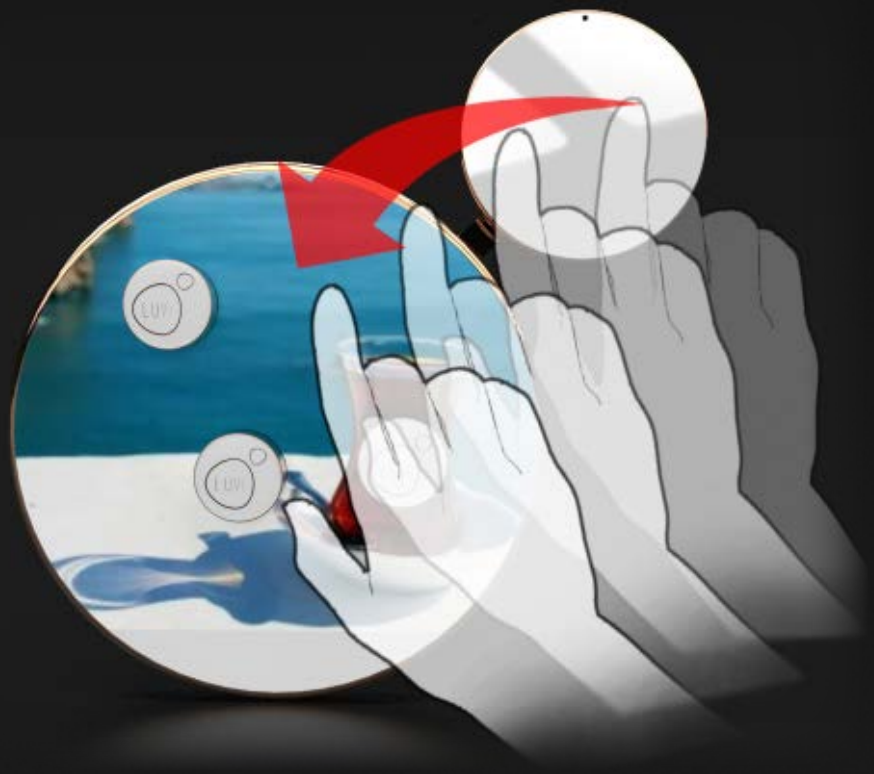
By returning to the main page, the user is able to switch to another menu, for example the image gallery.



The image gallery is made of the default images that are already loaded in the device, and the pictures loaded by the user through the camera.

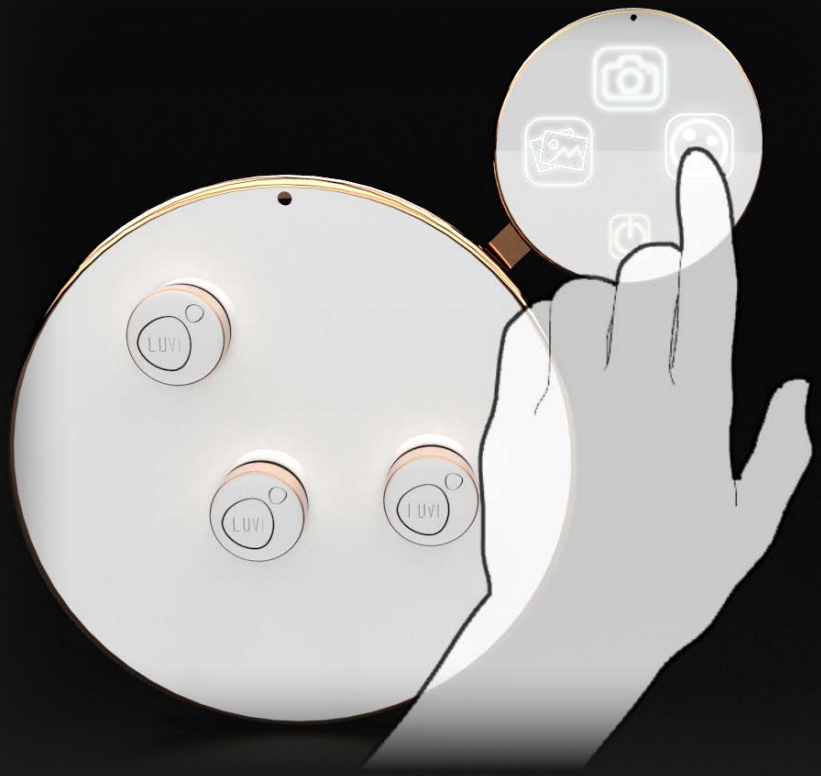
The gallery is in form of an archive, in which the pictures can be selected easily by changing them with a simple swipe gesture.

The light color can be observed synchronously. The lights change color depending on the image which is in front. This is a basic visualization with default settings and main colors selected randomly by the system. The only aim is to give an idea to the user.



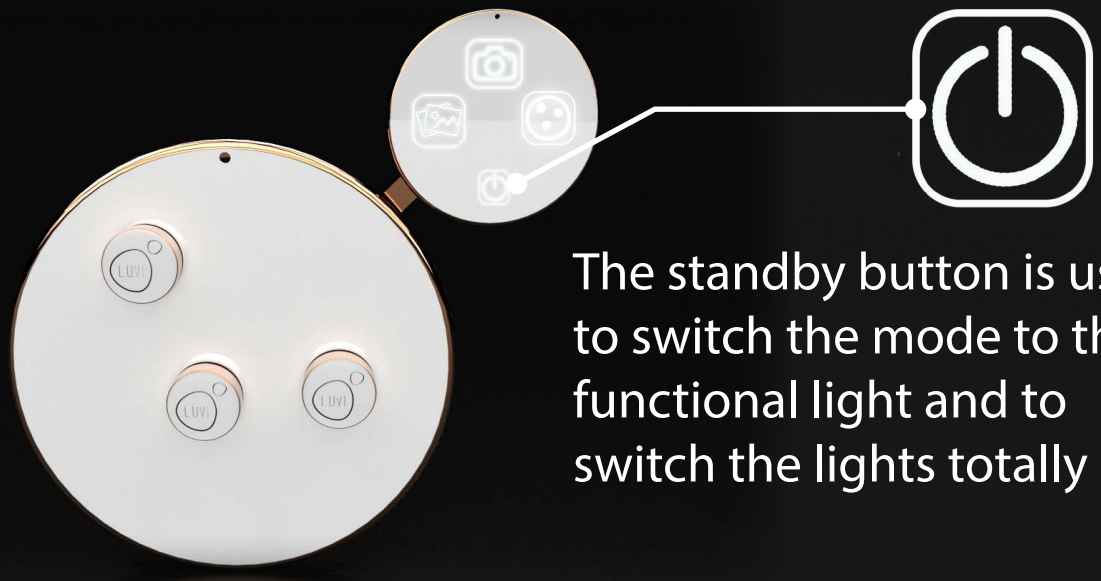
When the user decides for a picture, he has to swipe and drop it on the other screen for further adjustments.

After dropping the picture on the touch panel, the colors can be choosen by using the magnets. The same adjustment panel for the opacity, saturation and scale will be appeared and be available for adjustments as well.



By touching the color scale mode icon, the colorgradient ciecle is activated on the big touch panel.

The color can be adjusted by the magnets. The lamps can be turned off individually by moving the attached magnet to the black outer area.



The standby button is used to switch the mode to the functional light and to switch the lights totally off.

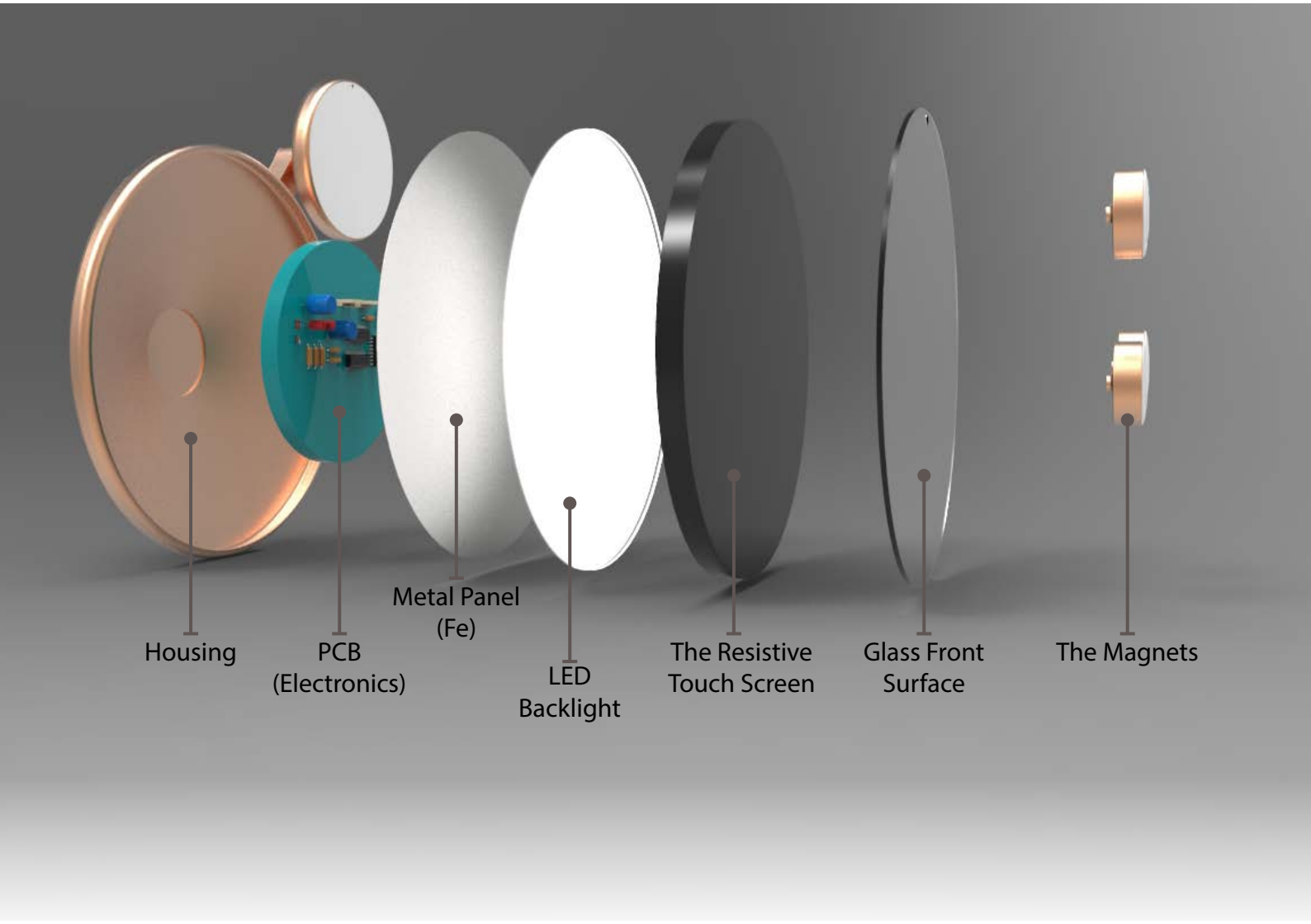
By applying a single tap to this icon, the device would be switchedto the functional light mode. (Plug&Play)

By a double tap onto this icon, the device and all the lights would be totally off.

This icon can be seen and used to switch the device on, even when the device is off. This part has a separated connection.

To match new lamps with the control panel, a service menu exists and activated with the two-finger touch interaction shown above. By using this menu, the new plugged LUVI lamps can be easily matched with the system and used for entertainment.

Exploded View and the Principle of Magnetic Control



How the Magnet System Works?

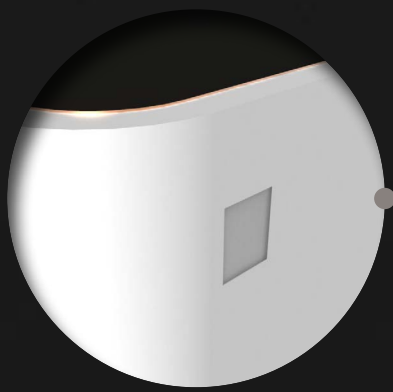
The Resistive Screen Module contains a metal panel made of iron (Fe) behind the glass touch surface and the capacitive screen is 'naturally' able to allow the passage of the magnetic field. So, when the magnets are placed on the glass surface, they are fixed by the magnetic field created thanks to the metal panel.

As explained in the research part (please see ...) the resistive touch screens do not work like the capacitive screens. The structure of these screens need a certain pressure in order to perform the function and sometimes they need to be used with special gloves or tools. As in this configuration, the resistive touch screen is placed between the iron panel and the magnets, it is within the magnetic field. So, the force applied by the magnet and the metal panel through each other by this magnetic field composes the force needed to use the resistive touch screen.

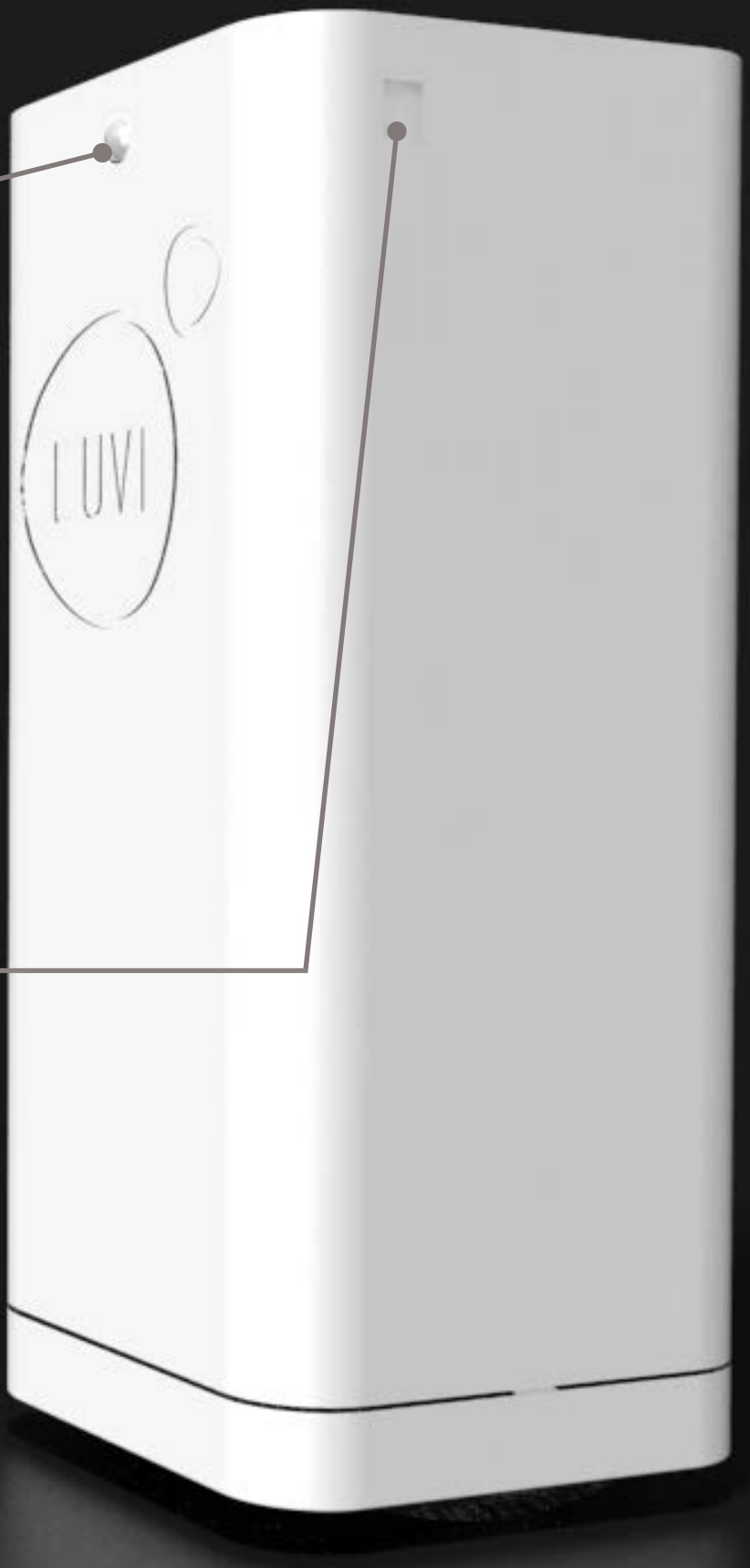
The Hardware of LUVI Modular Lights in the Upgraded Version

The Sensors

The HC- SR501 motion sensor is still present in the upgraded version, in order to provide the motion detection in the functional mode.

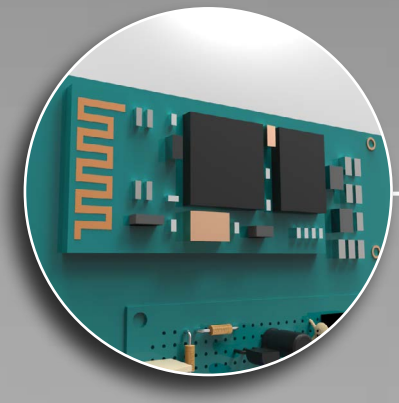


The Photo-diode is still present in the upgraded version in order to avoid the lamp to function when there is daylight or ambient light in the space.

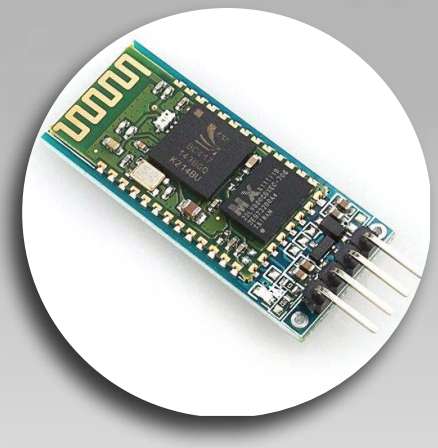


So, these two sensors are the default hardware of the LUVI lamps.

The Bluetooth Module



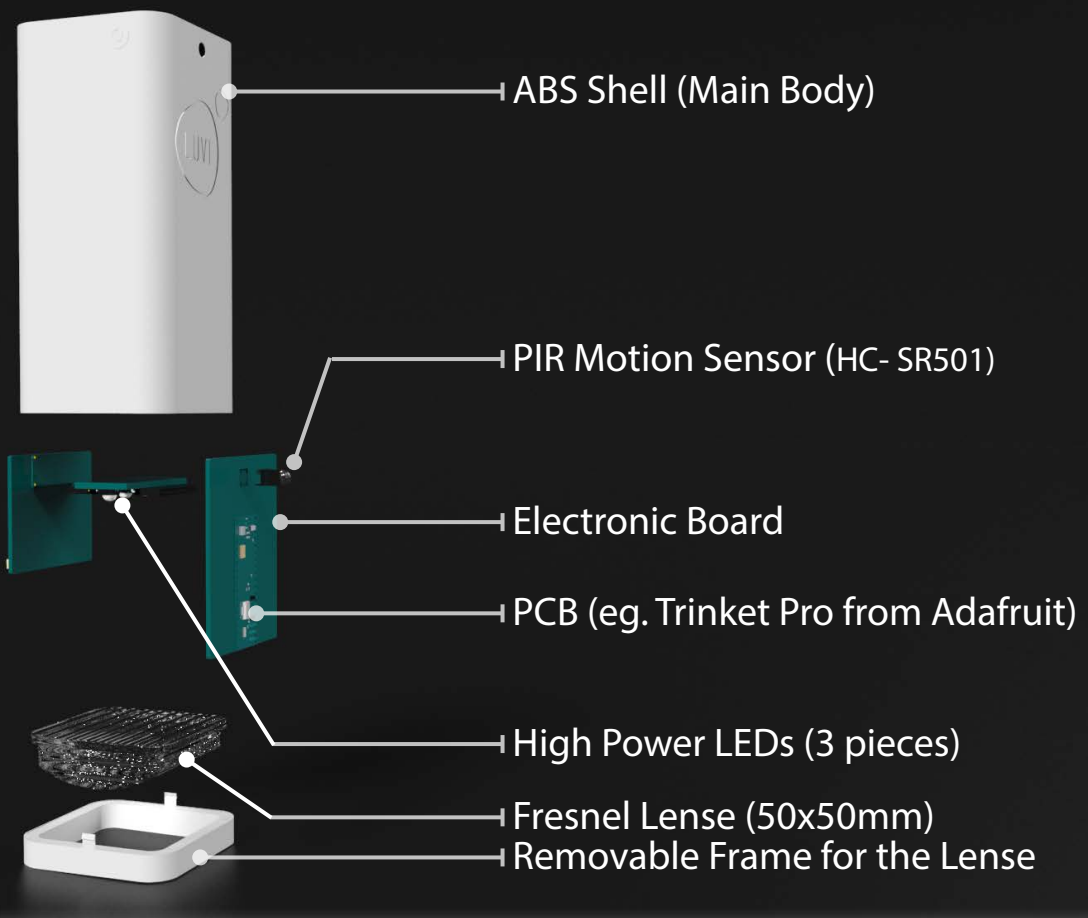
The component that makes the difference with the basic version is the used Bluetooth Module placed on the back top part of the lamp and that is invisible from outside.



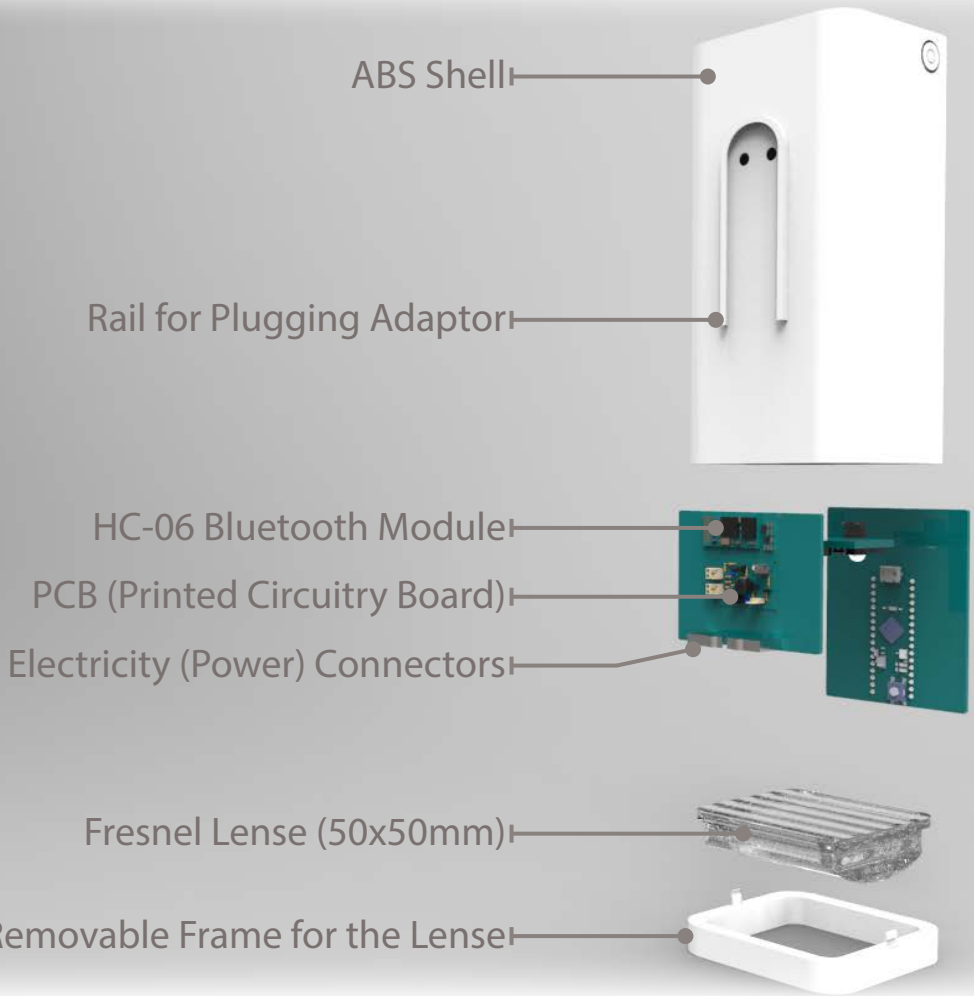
For the Bluetooth module, the selected example component is “HC-06 Wireless Bluetooth Transeiver RF Master Module” compatible with Adafruit Trinket Pro PCB

The Bluetooth Module is used in the upgraded version in order to provide connection with the Control Panel, while it was avoided in the basic version to reduce cost and complexity.

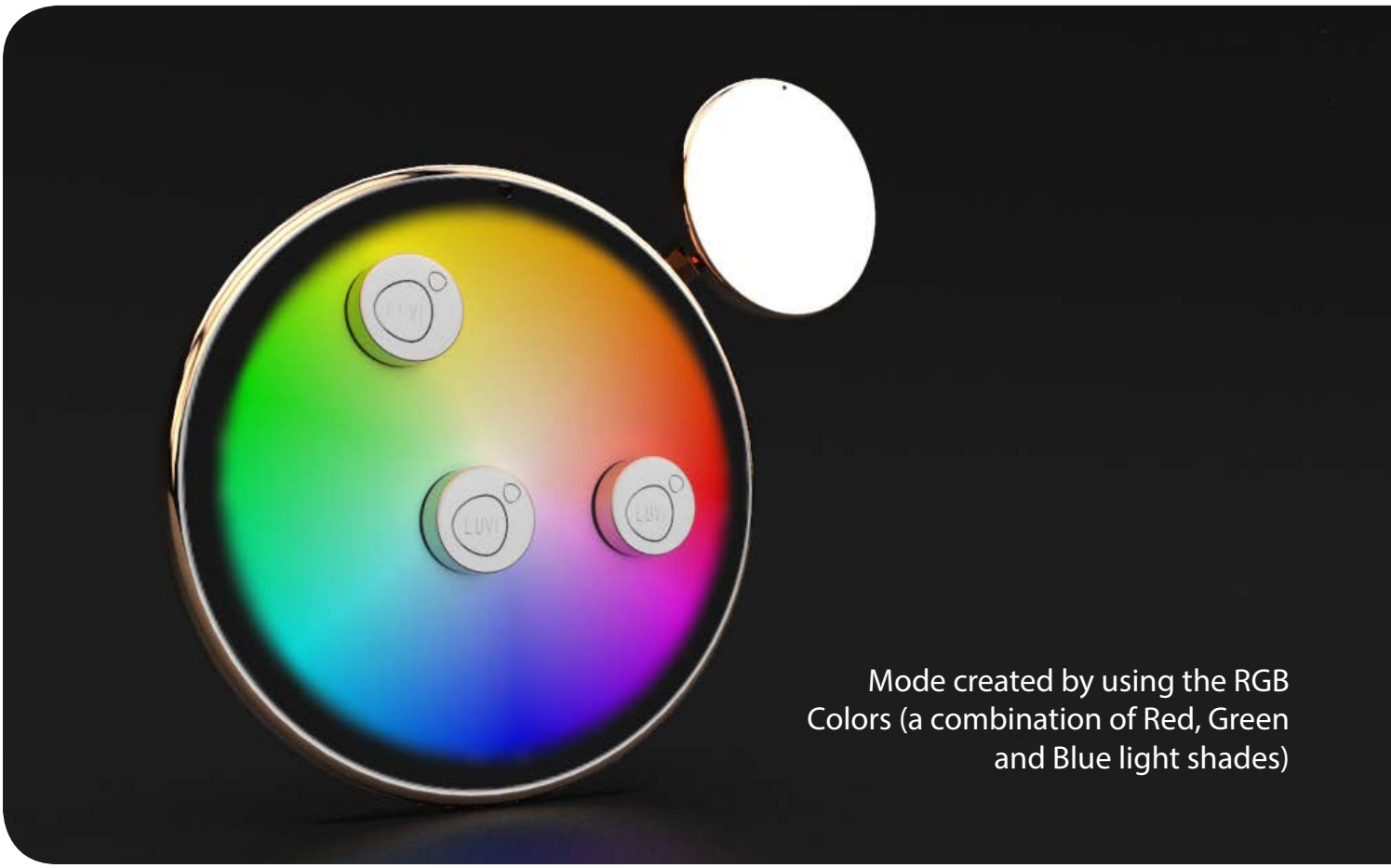
Exploded Views



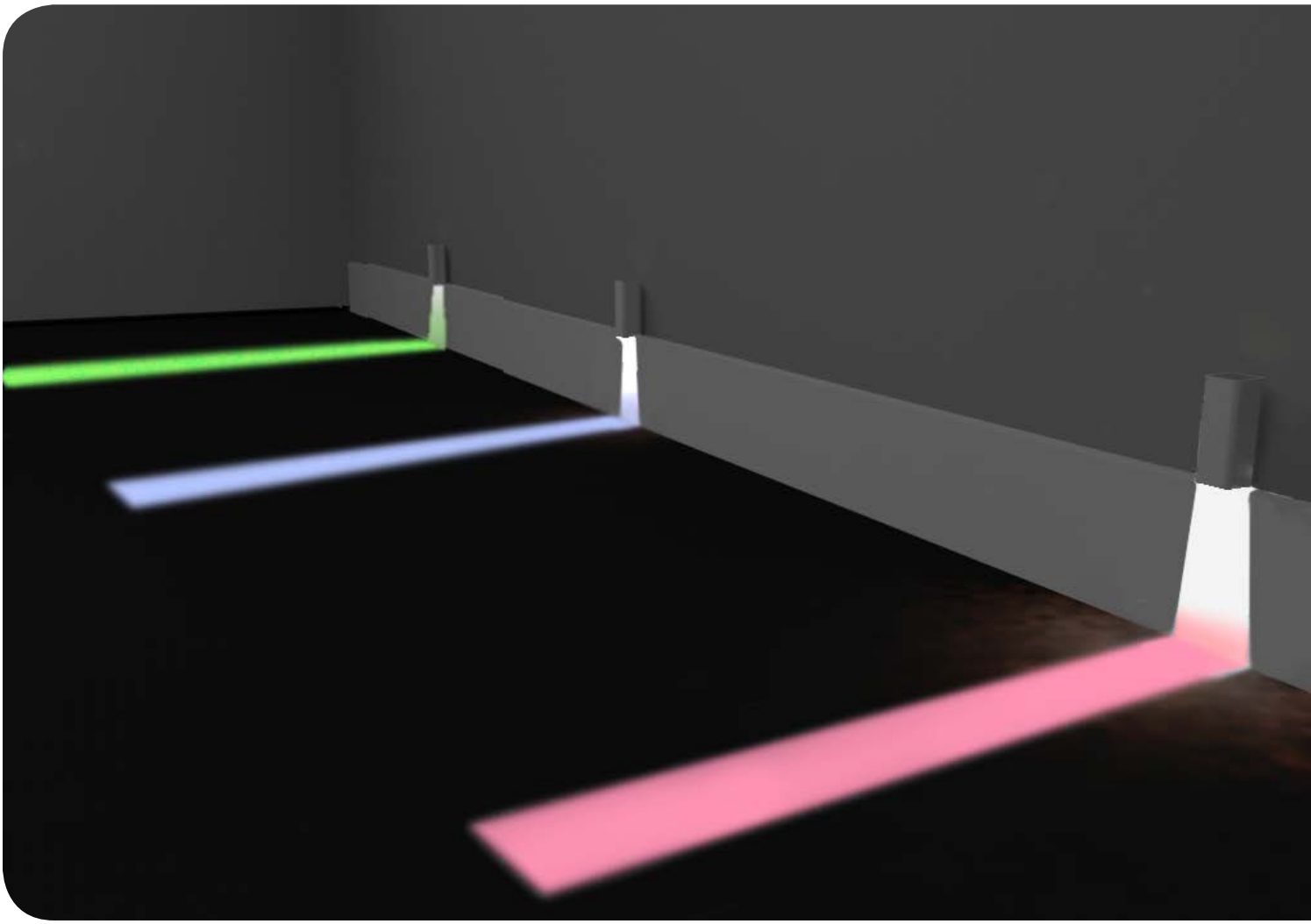
Front



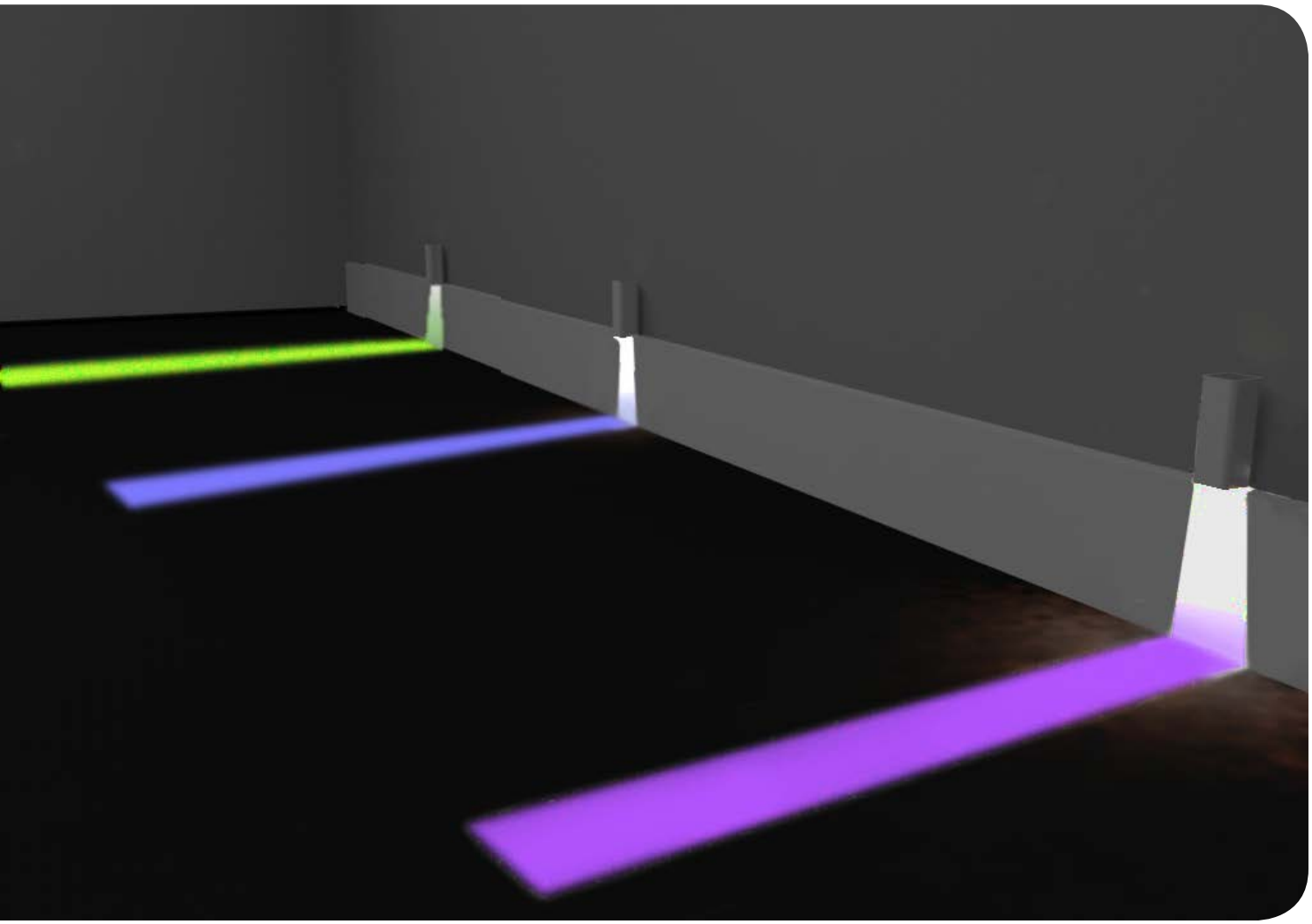
Scenes



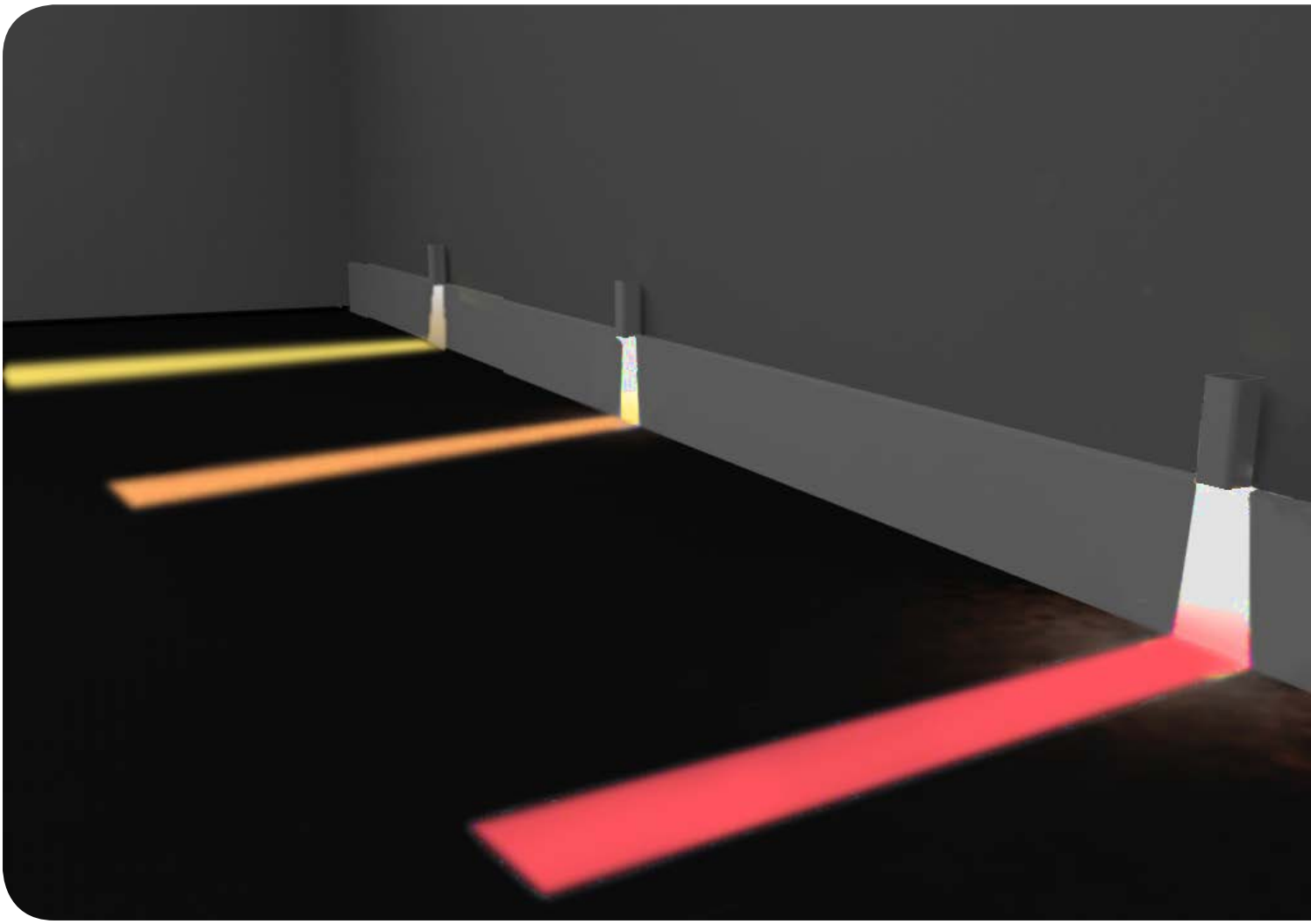
Mode created by using the RGB Colors (a combination of Red, Green and Blue light shades)

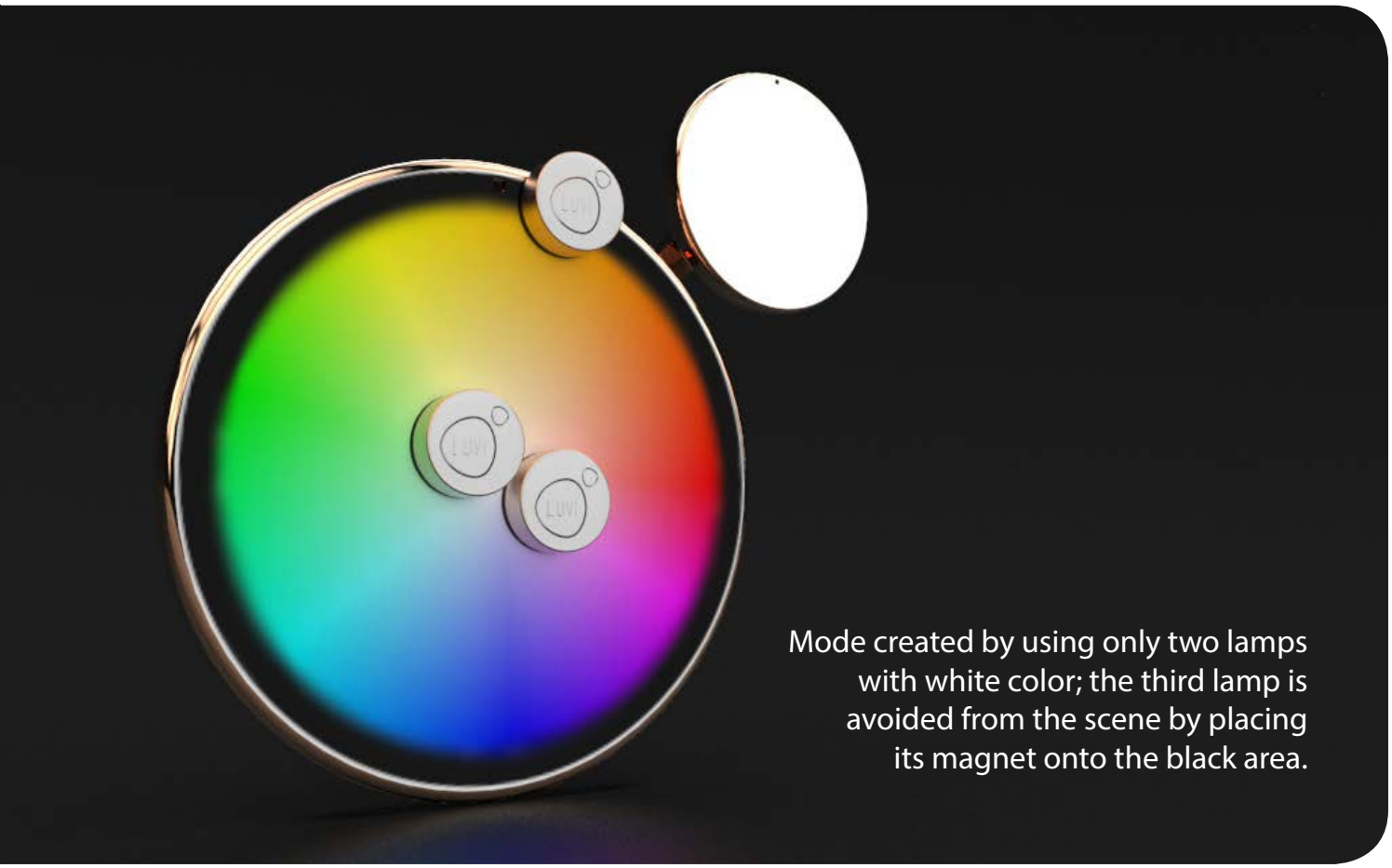


Mode created by using the cool tone shades; deep blue, purple and green.

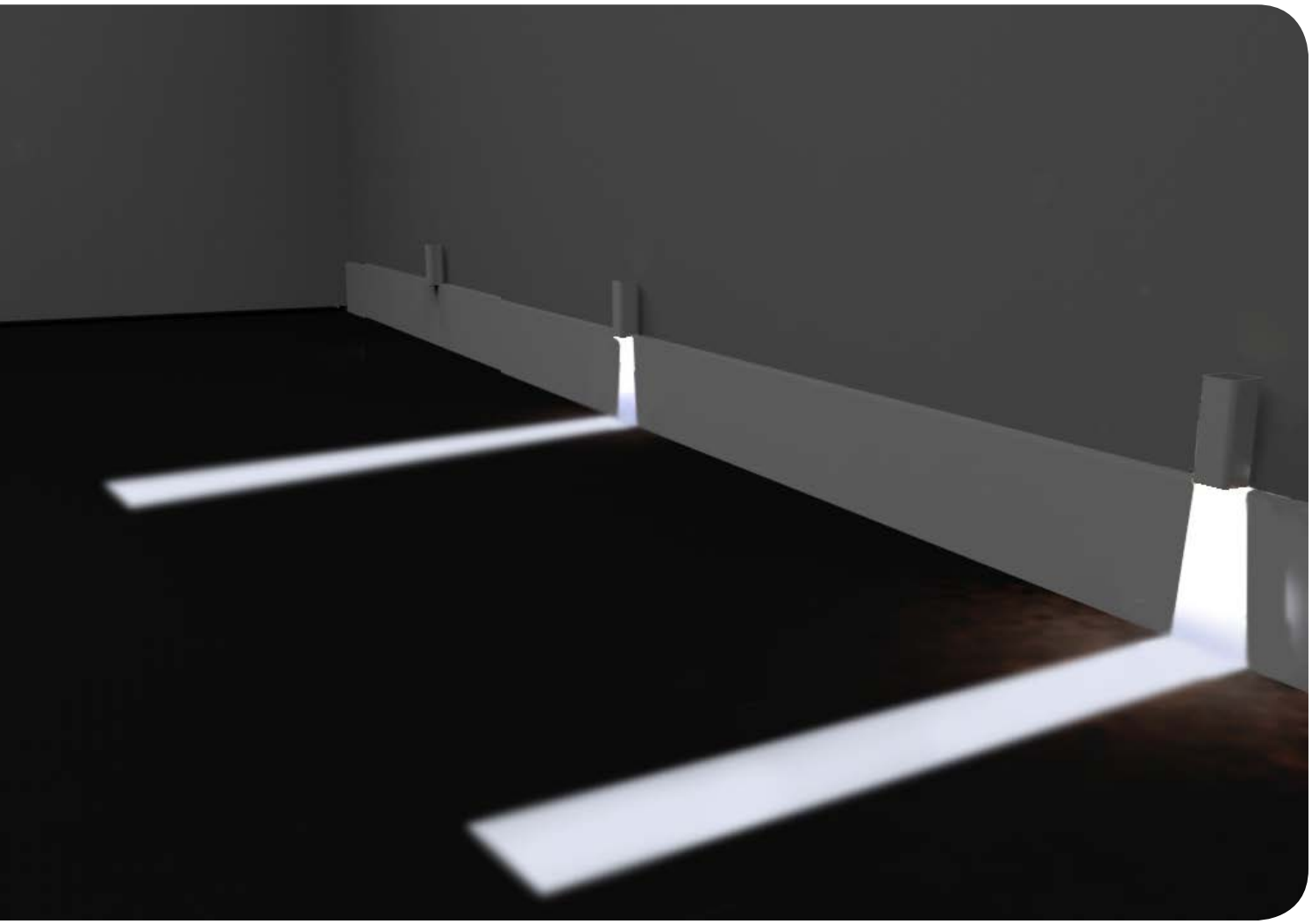


Mode created by using the warm tone shades; red, orange and yellow. *(This mode can be called as the 'Sunset Mode'.)*



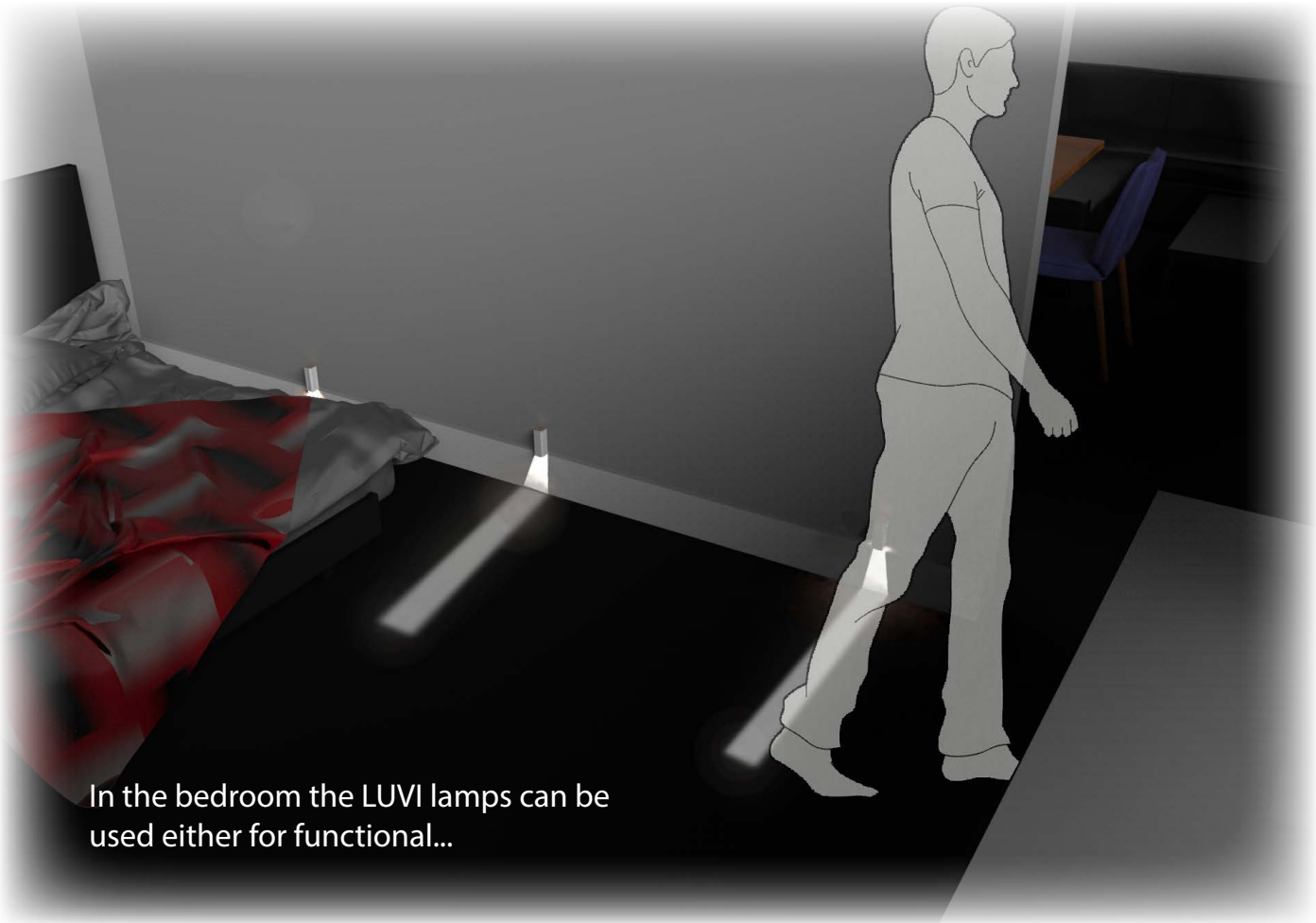


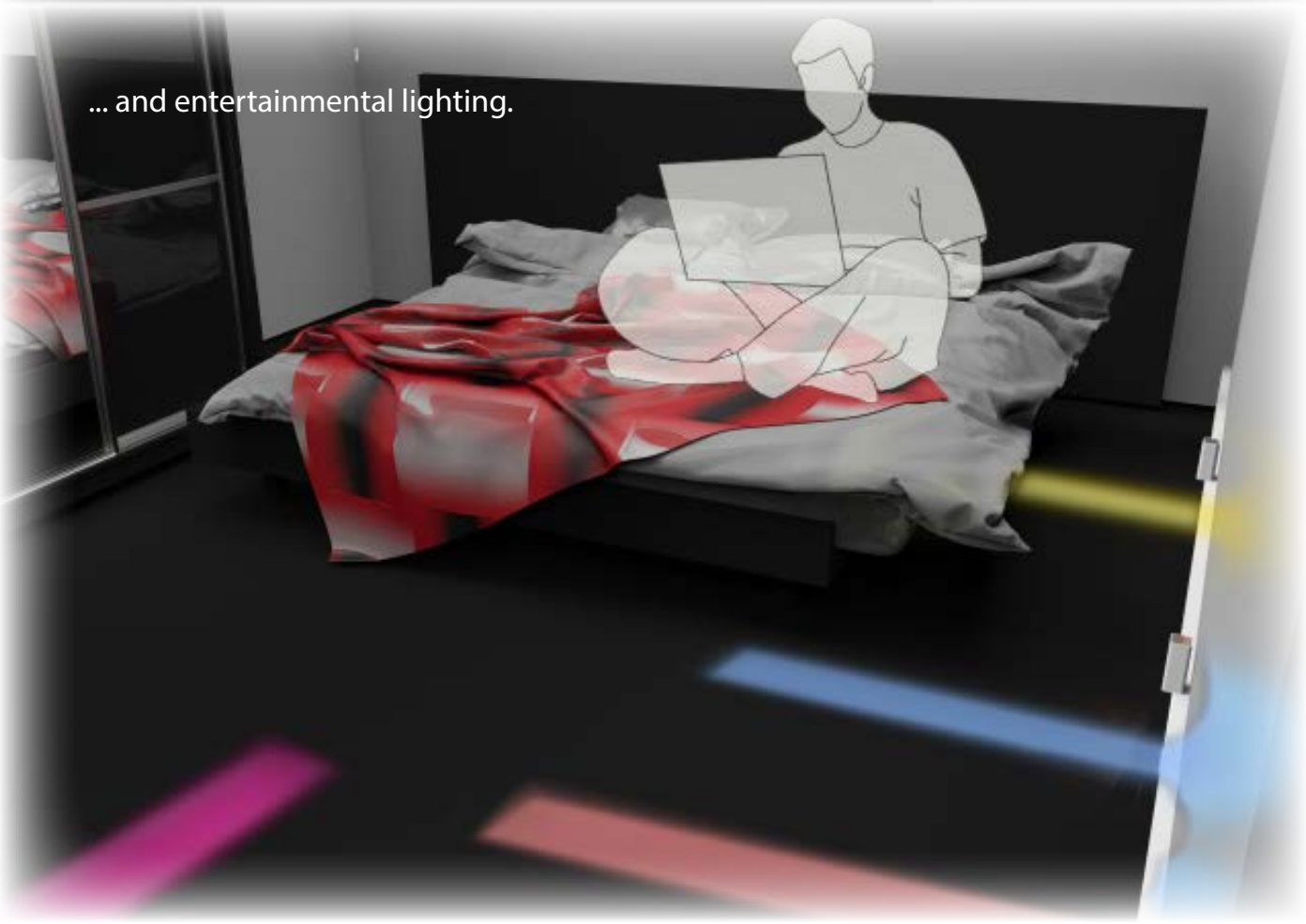
Mode created by using only two lamps with white color; the third lamp is avoided from the scene by placing its magnet onto the black area.



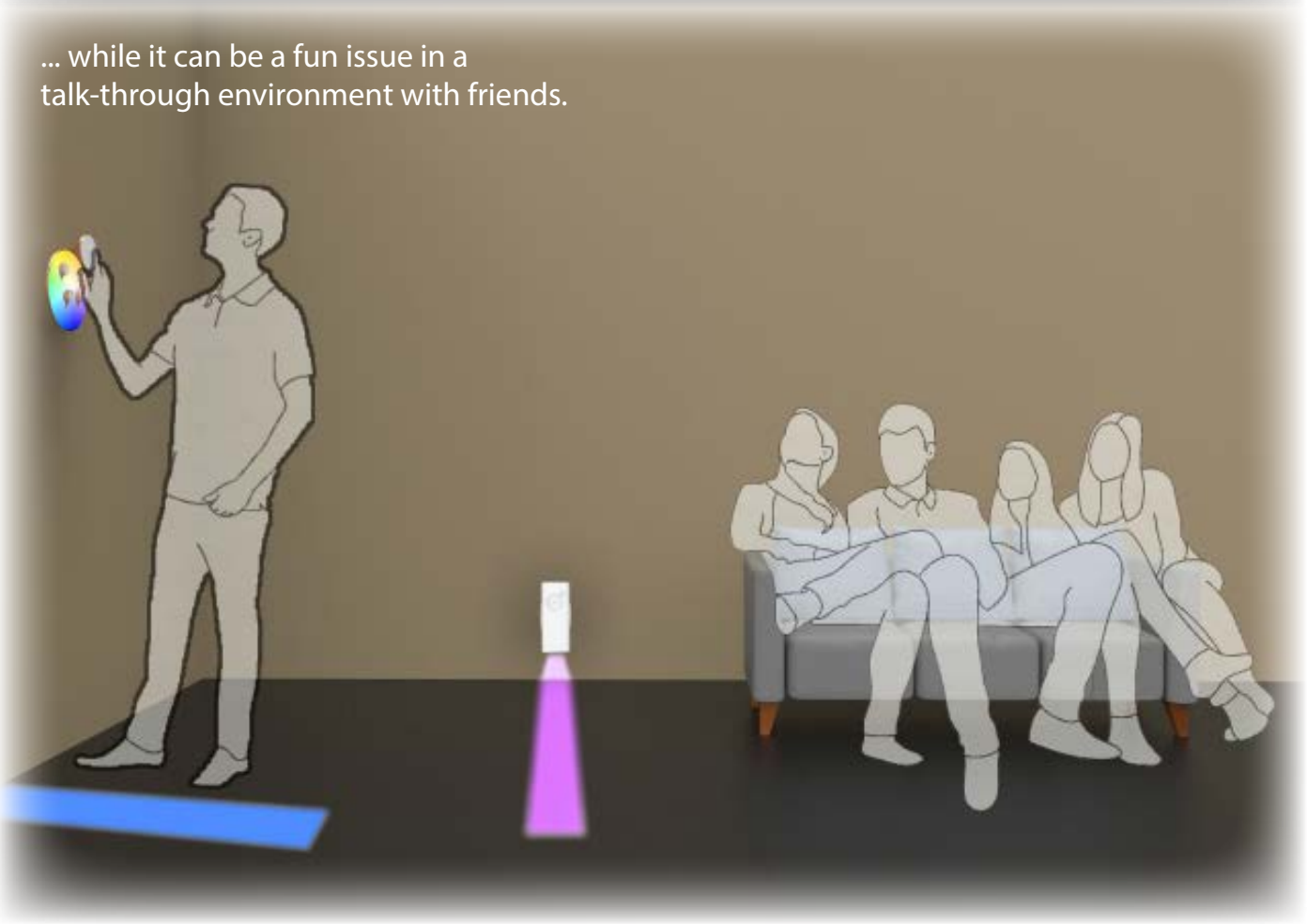
Scenes in Spaces

Possible Scenes in the Bedroom

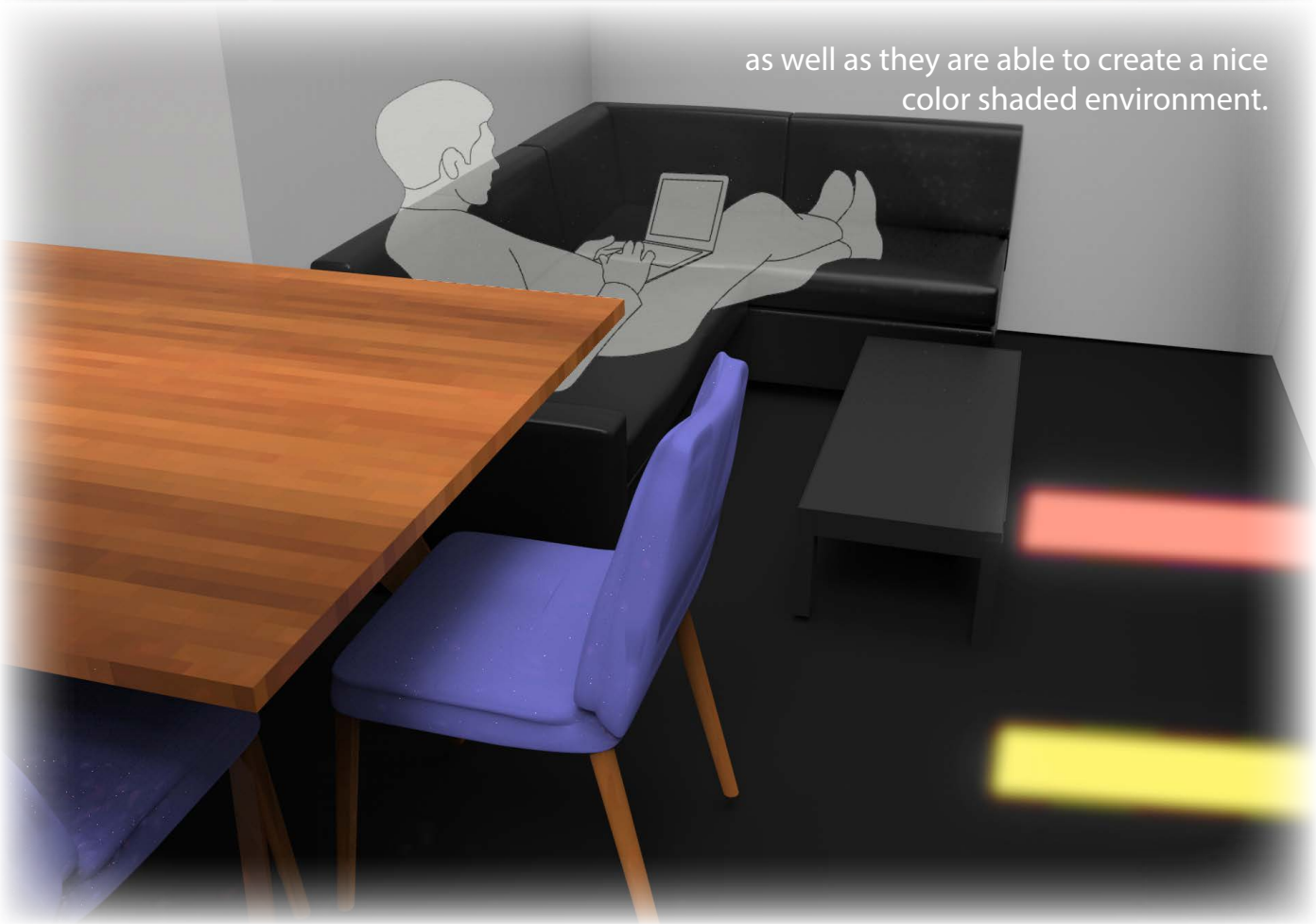




Possible Scenes in Different Modes



Possible Scenes in the Living Room



Possible Scenes in the Bedroom

The LUVI lights are useful for the children room too.

When the kid wakes up in the night and moves, the LUVI light would be activated and the child would not have fear from the dark.

Conclusion

The LUVI lighting project is a result of the whole research included in this thesis. The lamp is constructed by the use of technology by resulting the knowledge obtained during the research. The concept consists on two different modes of use by offering optionality on user experience and interfaces. The product has many advantages while has some limitations as well.

The biggest advantage of the design is the dual use optionality offering the user the chance to chose between a functional or entertainmental light. Secondly, the product is very small and can be installed easily; so that it can be bought by anybody for any interiors without the need of underconstruction. The optical structure of the lamp consists on limiting the diffusion of the light so it creates an effect that is useful and not disturbing the other people than the user. The upgraded version is a nice way to create ambiences in a room, while it can be personalized by uploading personal photos to set the color of light. Finally, it can be declared that the LUVI lights may be advantageous for a variety of people with several needs and expectations.

On the other hand, the optical system and the size of the lamp makes it unsuitable for an area lighting. The customer who would choose to buy a LUVI lamp could be a person with a specific need of a focused light. Additionally, the LUVI lamps need a number of electric sockets to be installed -that can be a problem for some houses- while the alternative is a permanent installation that limits the flexibility of the product.

So, this project was a work concluding the knowledge about the lighting technologies, lighting design, interaction design, interactive technologies and user experience design.

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Images

The resources of the pictures used for the Lighting Design Trends (4.2) and Benchmark Analysis (4.3 and 5.4) are shown within Sitography on the previous pages.)