The Effective Facades Lighting in Contemporary Architecture

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Abstract Since the design is less clear for the design idea during the night time, so, it is possible to enhance and activate the facades of that building at night using the attraction and excitement element, such as artificial lighting, and then building additional effects or hiding certain parts of the building. The search is limited to artificial lighting which is supported on the principle of stereoscopic deletion and addition in displaying the architectural facades in general. These visual forms are the result of the addition of a visible and intangible virtual stereoscopic interface, and thus, the addition to the building or deletion of part of it can be achieved, in addition to the formation of many interpretations of the building during the age of the individual. This could lead to the diversity and attraction of attention and staying away from boredom and thus increase interaction between the receiver and the building at night. Hence, the objective of the research was to increase the efficiency between the receiver and the building through the multiple interpretive readings of the architectural facade. Based on this, the research problem has emerged (the limits of the effectiveness of the facades lighting for the receiver in terms of multiple interpretations through light and shadow, and project it on virtual areas). A set of previous studies have been listed and then a cognitive framework has been built based on practical application. The results have been revealed that photo exhibiting illumination is better than video and flash exhibition which are accompanied by sound effects that create a kind of confusion, lack of clarity and loss the privacy of the building. The research also found that a large number of multi interpretations using deletion and shadow drilling, resulting from reading the architectural facade at night, does not affect its design during the day.

1. Introduction
It is self-evident to know that architectural projects are designed for the purpose of multiple readings aimed at the satisfaction of the individual and is a reflection of the information storage of the individual, that is, when the individual sees the design, he/she interprets it in time and this
mental perception remains constant often until the annihilation of the product or the individual himself, taking into account different individuals in their interpretations of the same design (that is, everyone has their own analysis and vision), by designing facades with several interpretive readings that give the building intellectual richness and trying to move away from the fixed shape of the facades, which thus reduces the individual's relationship with the building intellectually. Hence came the research problem of (the limits of the effectiveness of facades lighting of the receiver in terms of multiple interpretations through light and shadow and projecting them on virtual areas).

With regard to the objective of the research is (to increase the interpretations and visions of the single interface and thus increase interaction with the recipient and then strengthen the relationship between the building and the user, and this through the building of a theoretical framework related to this relationship). The hypothesis of the research is the following (the possibility of activating artificial lighting in the formation of several formal interpretations of the facade of the building in a short period).

The research methodology involves building an intellectual framework on the possibility of stereotyping in artificial lighting and the extent of interpretation, which includes a theoretical framework in which the concepts of the basic research elements are presented. The intellectual framework is also applied to a local or global model to determine the extent to which that framework is satisfied, and then to observe the results of that application and identify the possibility of application to the architecture that really needs those interpretations, after which conclusions are achieved and recommendations are made.

2. The first axis: the presentation of concepts

2.1 Part 1: The general framework of the concept of effective optical interfaces for the receiver.

2.1.1 The general concept of effectiveness.
Bartoli defines effectiveness as the relationship between the results already achieved and the results estimated by measuring the deviation.

2.1.2 Realizing the Effective Facades in Architecture:
Schulz pointed out that architecture is the outcome of human interaction with the place with a clear understanding of the architectural identity, where the social factor plays an important role in the achievement of architectural identity, that is, the architecture is achieved by the existence of an
interactive community and building to achieve an architectural identity.[14]. The perception of architecture revolves around the sense that responds to the tested architecture by adopting the multiple nature of perception through positive sensation and sensory stimuli, color, stereoscopic light, smell and its role, sound, space and density, and other sensory stimuli that interact the recipient with architecture.[9].

The biggest burden in making the facades light effective is through the art of lighting design, which depends mainly on several things before embarking on the process of lighting design, namely:

- The nature of the objectives required within the spaces of the building and the need for lighting according to the specificity of these objectives.
- Multiple levels of awareness for the recipients and thus provide their needs ideally.
- The objective of design.
- Basic standards in the design process.
- Lighting standards, patterns and how to control them.[4].

Consequently, the need for effective lighting architectural facades has emerged as a kind of modern technological development and processions with modern devices to increase interaction with the receiver and the user, as lighting has a role in the effectiveness of the facades and increase the receiver attraction as a living influence.

2.1.3 Stereoscopic and artificial lighting

It seems that the subject of stereoscopic lighting is closely related to the art of cinematography production related to virtual perception. A series of successive films by director George Lucas had been conducted attempting to visualize shapes in a technological way to produce video and stereoscopic films known as "Hologram". Twenty years later, the imagination of Lucas came true by the Hungarian Denis Gabor, who was awarded the Nobel Prize.[17]. this bold step opened wide horizons in the optical perceptions that have the possibility of the embodiment of light as a reality. The hologram is made by the separation of the laser beam into two beams, the first beam is projected on the object to be reversed using several lenses and mirrors organized and arranged in a precise geometric light format, the second beam is organized in such a way that it intersects with the light reflected from the object to be gravitated to eventually be known as "interference patterns". see Figures (1) (2).

![Figure (1)](image1.png)

**Figure (1).** optical interference patterns.[7].

![Figure (2)](image2.png)

**Figure (2).** Optical stereoscopy process.[17].

The other way to embed images with three-dimensional form requires the device (data show) for projection and this needs a surface to project the lighting, and can be the surface of the facade itself or create another transparent surface can be considered as mobile and flexible, which falls on the images by the projector.[18].
It is clear from the above that there is more than one way of 3D projection on the facades of the building. One of these methods is the laser projection which adds visible and intangible forms that can be used to add an element to architectural buildings through a stereoscopic image. It is, therefore, possible to add any shape to any building which will make the facade of the building digital in nature but in this way there is no shadow. The other method requires a data projector (data show), which depends on the surface on which the light falls. Three-dimensional projection can be performed by using three surfaces, on each surface an image is projected from a specific source and from certain angles, thus producing a three-dimensional shape. What distinguishes this method is the possibility of forming and designing the shadow in the presentation.

2.1.4. Lighting and receiver interpretations (lighting and hormonal)

Heidegger (the year) pointed out that hermeneutics is one of the areas in which an individual can decipher the words that related to places, times, and literature without adding words or language of the individual or the recipient.[10]. Walter Otto (year) explained that the hermeneutic approach was designed in order that the text refers to the treasure it contains, and the interpreter has to lead the reader to that treasure and then come out to be completed by the reader.[10]. The interpretation (hermeneutic) is an internal demand towards things remains always urgent and is also a moral requirement and should bring out all the spiritual and intellectual forces for interpretation performance process, and also depends on the information storage.[11].

Accordingly, the subject of the research in increasing the number of interpretations pertains to the clear architectural facades that do not attract attention by the recipient and thus increase the recipient's interaction with the facade, which is done by adding ideas using the element of artificial lighting for several reasons:

1. A flexible component in architectural forming and design in terms of implementation and the possibility of making any required form.
2. Do not affect the main facade of the building because it can be easily removed and does not affect at all in the day.
3. Linking historical interfaces with contemporary technology using projectors.
4. Its operating cost is fixed.

2.2 Part II: Theoretical Framework

2.2.1. The general framework of the concept of optical interfaces

For the purpose of building the cognitive framework for optical effective interfaces with multiple interpretations, the previous studies will be discussed to address the most important reasons that highlighted the subject of lighting in the architectural facades and to derive the most important elements necessary for research, of these studies:

2.2.1.1 Study of Rana Mazen Mahdi, 2008

It dealt with the process of lighting design to impart a set of influential aspects that enhance the importance of architectural output, which is mainly focused on the expressive aspects of the influential night scene and thus create a positive social interaction in the architecture and may ensure the achievement of architectural identity. The purpose of the study was to find out how to design night lighting that facilitates the work of the designer in accessing the subject of the formation and design of night lighting.[5]. The research reached the non-directness in the expression and emphasis on the most important element in lighting and remain the lighting of the rest of the elements as a background of the basic element. The study stressed the need to take into account the planning of the design of lighting design in the early stages and that it does not delay to the end where it will be the collection of what is happening, and there is doubt of it. The study preferred to use several lamps that should be small and distributed throughout the building better than one lamp taking into account the external corridors, lakes and gardens and take them into account when designing night lighting putting a mechanism of how to study and plan the night
lighting design of buildings, which increase the aesthetic of the building and thus increase the interaction.[5].

2.2.1.2- A study of Safaa Al-Din Hussein and Zainab Abdul Hadi, 2009
This research has studied the impact of artificial lighting in the visual revelation of the facades, which dealt with the subject of light and artificial lighting and study the characteristics of light, namely, direction, intensity and color, as well as knowledge of the visual and morphological characteristics of the facades, which divided the facades as a form into: regular, irregular and mutant forms.[6]. The study revealed a number of conclusions about the nature of light and its relation to changing the recipient's sense and impressions. It concluded that the light works to embody the sense and create special moods with the ability of high expression and visual intimation of the facades through its influence in the form depending on the receiver, the nature of the visual formalities of the facades, and the properties of optical light. It also showed that the phenomenon of artificial lighting is important in bringing about change in the area of action and formation in architecture by manipulation and modulation in artificial lighting according to the need and desire for the influence of technical light variables and characteristics: direction, intensity and color.[6].

2.2.1.3 A Study of Zumtobel, 2012
The study dealt with the subject of projected lighting in the architectural facades using LEDs lighting type. The aim was to ease the transmission of the message to the recipient and increase communication and create interest and interaction. The study considered that addressing this type of lighting is a modern development with lighting techniques as well as the need for a community to lighting display in addition to commercial promotion. The availability of these lamps (LEDs) makes their use in the facades economical with the possibility of controlling the display method. This method provides multiple designs and is successful in the display on architectural facades taking into account the absence of light pollution. Moreover, the study addressed a number of implemented global projects and how they affect the recipient and try to draw attention.[15].

2.2.1.4- A Study of Ana Teresa, 2013
This study dealt with the relationship between architectural and optical design and that optical design is part of the mission of the architectural designer and should be considered as an architectural issue and not only artistic, and take the same attention in structural thinking. The study dealt with lighting design and ultimately how to show architectural aesthetic using different lighting tools, including lighting emitted towards the building and emitted from the building to the recipient, which can contribute to increasing the interaction between the receiver and the building. Moreover, this study addressed the importance of the design of integrated lighting for buildings, where there is a necessary need for integrated lighting by the receiver and is considered a psychological need must be realized for the receiver in buildings. In addition, the multiple interpretations of lighting from time to time contribute to increased interaction. The lighting has been classified into visible and hidden, and the hidden lighting is preferred in order to avoid visual dazzling as it is possible to design shadow as a kind of architectural lighting design.[16].

2.2.1.5 A Study of Dania Abdel Rahman, 2013
The study dealt with the effect of artificial lighting in the forming of the night scene of outer spaces through its patterns and characteristics. The study conducted an on-site questionnaire in which a set of favorite features were used by the users of outer spaces at night. It was concluded that the most influential optical properties and patterns in achieving the form elements, that are, direction, intensity and colors. The direction included five directions (top, down, head, back and side lighting). The incident light intensity affects the optical properties through (sharpness, contrast, color attributes, texture, shadow strength, size, change in the time of vision and light value), while color is a means of self-expression and a manifestation of aesthetic sensation. The research
provides a design of the state of lighting and determines the location of lighting, color and intensity in the design of night lighting in architecture.[7].

2.2.1.6 A Study of Nader Khalil Mohammed, 2015

The study dealt with the role of night lighting in highlighting the architectural aesthetic form of public buildings, where it was devised that the axes of aesthete that appear through the night lighting are (shape, color, texture, finishing materials and structural system). The study also considered a number of international architectural projects and how to deal with night lighting and ideas to highlight these projects, which is considered as an indicator of the extent of the strong relationship between architecture and night lighting, and the ability to influence and change the psyche of the recipient. The study also dealt with how to show the aesthetic of architectural buildings only such as the reflection on water and show the structural form by night lighting using an unspecified number of colored lamps, especially the LEDs focusing on the basic elements of the building.[8]. It also showed that there are three requirements to achieve the optical interaction between the receiver and the building: the visible object (objective/building), lighting conditions, the viewer or the receiver. The visual object depends on the size and area of the visible body, body lighting, the contrast in lighting between the body and the media, the duration of vision, the type of body, the type of ambient medium and the accuracy required. The lighting conditions depend on the level of lighting, glare (dazzling) and colors. Finally, the receiver depends on the conditions of the eye, the level of adjustment, the degree of stress, reaction, and psychological state.[8]. Finally, after the presentation of all the previous studies, the basic indicators that have drawn from them will be introduced as in Table (1).

Table (1). The elements extracted from previous studies

| Elements Extracted from Previous Studies | Studies |
|-----------------------------------------|---------|
| Intensity and visual dazzling | Rana Mazin |
| Optical Area | * |
| Lighting location | * |
| The role of shadow | * |
| Real-time optical manipulation | Indirectness |
| Multiple interpretations | Mental state |
| Sensation | Sensation |
| Directness | Directness |
| Highlight elements | Highlight elements |
| Rana Mazin | * |
| Safaa & Zainab | * |
| Zumtibel | * |
| Teresa | * |
| Dania Abdul-Rahman | * |
| Nadir Khalil | * |
2.2.2 The discussion:
From the above, it is clear that the studies focused mainly on the psychological state and the embodiment of sensation in the level of interaction of the receiver with the optical interface, followed by the location of illumination and then highlight the elements like intensity and dazzling of light and then non-directness, while did not address more than one study on the subject of multiple interpretations and the role of shadow and light spaces and their impact on the level of interaction between the receiver and the building. Through the review of a set of studies above, it was obtained numerous points that discussed the impact of lighting in the effectiveness of architectural facades, which helped to find a number of theoretical frameworks related to architecture with effective optical facades. These elements were extracted according to the intellectual opinion of each researcher for getting effective optical buildings and their level of impact on the receiver.

The main elements of multiple interpretations are (multiplicity of readings, effective shadow and active light area).

2.2.3 Abstract of research vocabulary derived from previous studies

| The possible values                          | Sub-Elements          | Key Elements                                      |
|----------------------------------------------|-----------------------|---------------------------------------------------|
| Animations for short periods of time         | 3D                    | Photo Reading                                     |
| Animations at weekly intervals               | 3D                    | Types of readings                                 |
| Animations in annual intervals               | 3D                    | Addition by Light                                  |
| Animations for short periods of time         | 3D                    | Multiple Readings                                  |
| Animations at weekly intervals               |                       | Effectiveness of the optical interface            |
| Animations in annual intervals               |                       |                                                   |
3. The second axis

3.1 Practical application

A questionnaire was conducted for the elements involved in the subject of research as a practical application of the theoretical framework on a set of Arab and international architectural projects because it was difficult to find a local example. The questionnaire was distributed to a group of experienced architects, both males and females, with 20 questionnaires. The information of the questionnaire was collected and the results were analyzed.

| Variables Measures | The possible values | Sub-Elements | Key Elements |
|--------------------|---------------------|--------------|--------------|
| 3                  | Animations for short periods of time | 3D | Photo Reading | Multiple Readings |
| 2                  | Animations at weekly intervals | 3D | Video Reading | Effectiveness of the optical interface |
| 1                  | Animations in annual intervals | 3D | Types of readings | |
|                    | Animations for short periods of time | 3D | Addition by Light | |
|                    | Animations at weekly intervals | 3D | | |
|                    | Animations in annual intervals | 3D | | |
|                    | With sound effects | 3D | | |
|                    | No sound effects | 3D | | |
|                    | With sound effects | 3D | | |
|                    | No sound effects | 3D | | |
|                    | Acoustic | 2D | Flashing effects | |
|                    | Silent | 3D | | |
|                    | Acoustic | 3D | | |
|                    | Silent | 3D | | |
| 3                  | Shadow design | Shadow Formation | The Effective Formation |
| 2                  | Design light and shade together | Deletion by Shadow | |
| 1                  | Change the perimeter of the shape | | |
|                    | Drill inside the shape only | | |
| 1                  | Steamy | Virtual Unreal | The Effective Optical Area |
| 1                  | Intangible | Physical | |
| 1                  | Rooftop | | |
accompanied by sound effects, as well as the diversity of the projection during the hours and days. The display is on the façade of the building itself, therefore, the shape of the building determines the nature of the display somewhat, where the display area is hierarchical and no virtual surface can be added outside the boundaries of the building to complete a scene. On the other hand, the shadow as the background of the projection is imperceptible and neglected. In addition, the projection based on the shape of the building is two-dimensional and not three-dimensional.[19].

3.2.2 Headquarters of Audi - Ingolstadt / Germany
The Audi projector of Audi company is characterized by impressive flashing lighting using LED lighting as a sales promotion. The lighting is accompanied by sound effects that gave the luxury for the company and its production as the characteristic of cars is the high luxury, which came to the purpose of pulling customers to interact with the product. Architecturally, the interface lost its value at night despite the beautiful exterior for the special projection facades because the target behind the artificial lighting is a commercial objective and not for another purpose.[20].

3.2.3 Cathedral of Santiago de Compostela, Galicia/Spain
The greater Cathedral of Spain, located in the city of Santiago de Compostela in the Galicia region. The spectacular projection is characterized by three-dimensional high-technology through the incidental lighting (data show), which was installed with high-precision photovoltaic architecture. This building specializes in the unique photo and video projection accompanied by the sound effects on the roof of the building itself that attracts the receiver. The projection included the history of the building since its inception and the events that took place in a stereoscopic manner. The shadow played a prominent role in the construction of the perimeter of the shape or drilling within the shape of the space in addition to the work of three-dimensional shapes. All of which increased the interaction of viewers with the building and learning about the history of the building through a wonderful presentation.[21].
3.3 Analysis of the results

After analyzing the data from the questionnaire for the selected projects, the following results were found:

The interaction between the architectural facade and the recipient increases with the multiplicity of readings. Through the image formulation, it is found that the rate of acceptance of the reading of three-dimensional picture reading increased by 74% more than the two-dimensional readings which was 26% as a role in the multiplicity of interpretations, as well as the multiplicity of the picture readings increase by 67% more than the video reading which was 18% and the flash effects by 15% (Figure 10). The amount of photographic multiplicity of the three-dimensional daily lighting was 33%, while the weekly lighting was 41% and the annual change of the three-dimensional light form was 26 % (Figure 11).

For the use of video stereotyping (video images), the results came with the superiority of silent display that was 77%, while the other rate of 23% was for the video-audio presentation. As the architectural acoustic interface approaching the directness in the transmission of the message to the recipient, the purpose was the promotion and mental attraction as an impact, as well as for flashing with the same proportions (Figure 12).
For the shade, the results were 76% for light and shadow design, and 24% for shadow design only, and the deletion by shadow was 55% by deletion from the perimeter of the facade and by 45% through drilling inside the facade (Figure 13).

Correspondingly, the area of the projected light, which was favored by the data, was flexible and transparent vision by 81% because the multiple interpretations require a flexible surface and does not affect the facade in the day and higher technical, while the normal physical surface (the surface of the facade itself) has a rate of 19%, where the others require constant commissioning and maintenance (Figure 14).
4. Conclusions

- The photo illumination project can be considered better than video and flashing projection, especially those that change its composition weekly, because the change in design daily does not allow all individuals to see the new form and on the other hand may be the shape that changes daily cannot be absorbed at the same night, in addition to confusion in the privacy of the building. At the same time, the shape that changes annually will certainly create a kind of boredom, while the optical form which changes every week is the best ways to accommodate and create a state of response to the requirements of the recipient, and thus, the weekly photo light is the most effective and therefore multiple Interpretations of the recipient.

- Video and flash incidental lighting create a kind of confusion and lack of clarity and loss of privacy of the building, so it is not recommended to be used, especially that accompanied by a sound effect.

- Video and flash lighting for shops can be used for advertising promotion.

- The possibility of adding three-dimensional visual blocks and physically intangible to the interfaces that suffer poor in the formations and influential elements.

- The possibility of integrating the intercalated buildings by adding or deleting the undesirable element in the buildings to be added within the context of the urban fabric occasionally.

- Through the photographic lighting exhibiting, multiple readings provide a desire for the recipient to discover the new format resulting after each week and thus creates a continuous communication between the receiver and the building.

- Two-dimensional video lighting projection can be used for occasions and celebrations without artificial surfaces.

- The multiplicity of interpretations in the architectural facade does not affect the design of the facade during the day because the surfaces used can be easily controlled.

- The fixed form in the daytime and weekly multiplicity in the readings at night.

- Multiple interpretations using deletion and drilling in the architectural facade using shadow.

- The use of projectors (DATA SHOW) that are capable of producing this perception in addition to the use of (hologram) lighting type for digital display, and must be characterized by specific characteristics, such as the range, accuracy and resilience to changing conditions.

- There is a close link between the architect and the mechanical engineer in the success of this technology, especially in the installation of projectors.

- There is a link between the architect and the sanitary engineer in the installation of water spraying devices (nozzles) and how to design and make them suitable for the architectural requirement.

5. Recommendations

- The research recommends using this technique in interior design.

- The research recommends the taking caution in the use of this technique in heritage and religious buildings.

- The role of the sanitary engineer in the drainage of water of the virtual surfaces or exploited them in a designed manner.

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