A Guideline for Virtual Reconstruction of Historical Facades, 3D Projection Mapping Approach

Bahareh Mohammadzadeh Moghaddam

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Prof. Dr. Elvan Yılmaz
Director

I certify that this thesis satisfies the requirements as a thesis for the degree of Master of Science in Architecture.

Prof. Dr. Özgür Dinçyürek
Chair, Department of Architecture

We certify that we have read this thesis and that in our opinion it is fully adequate in scope and quality as a thesis for the degree of Master of Science in Architecture.

Assoc. Prof. Dr. S. Müjdem Vural
Supervisor

Examining Committee

1. Prof. Dr. Uğur Dağlı
2. Assoc. Prof. Dr. Resmiye Alper Altun
3. Assoc. Prof. Dr. S. Müjdem Vural

ABSTRACT

During this study historical buildings and different types of lighting on historical facades are introduced, in general, and then specifically, 3D projection mapping on the facade of historical buildings, in order to create a context for proposing a new idea to apply this technique on the historical facade. Through the study the capabilities of 3D projection mapping on historical facades in artistic exhibitions was investigated. The researcher uses capabilities such as high quality of lighting, presenting realistic images, masking capabilities, as well as high clarity of the images from the distance for suggesting an innovative method for reconstructive purposes. Visual reconstruction of the historical facade as a new suggestion contributes to the preservation of the identity of historical buildings which utilizes a 3D projection mapping to display the reconstructed image of the facade of the historical building onto the facades with high quality and 3D method.

The present study seeks to introduce a new guideline for the implication of 3D projection mapping in absorbing the audience to reconstructed building virtually. 3D projection mapping has been used commonly for projecting images onto the facade of buildings by using light to revive the historical context. This technology has the ability to operate new functions as a media for creating a relation between the building and the viewers. Video projection mapping works are categorized into several types such as the methods of projecting onto buildings; the present study attempts to propose a guideline for using 3D projection mapping and categorize it in artistic or entertainment, advertising and specifically reconstruction.

Keywords: Historical Facade, Visual Reconstruction, 3D Projection Mapping, Virtual Facadism

ÖZ

Bu çalışma tarihi yapıların sanal olarak tekrar yapımını sağlayarak kullanıcın dikkatini çekmeye çalışan 3D projeksiyon haritalama uygulaması için bir yeni bir kılavuz önermektedir. 3D projeksiyon haritalama genellikle yapının cephesine görüntü yansıtarak tarihsel bağlamı canlandırmak için uygulanmaktadır. Bu teknoloji yapı ile seyirci arasındaki iletişimi yapılandırmaktadır. 3D projeksiyon haritalama çalışmaları uygulama yöntemlerine göre sınıflandırılmaktadır. Bu sınıflandırma da sanatsal ya da eğlence, reklam amaçlı uygulamalar söz konusudur.

Bu çalışma sırasında genel olarak tarihi yapılar ve farklı aydınlatma ile tarihi cepheler tanıtıldı ve detaylı olarak yeni bir fikir olarak tarihi yapıların yeniden yapımı için 3D projeksiyon haritalama uygulaması anlatılmıştır.. Yeni bir öneri olarak tarihsel cephenin görsel yeniden yüksek kalite ve 3D yöntemi ile cepheler üzerine tarihi binanın cephesinin yeniden resmi görüntülemek için bir 3D projeksiyon haritalama kullanılarak tarihi yapıların kimliğinin korunmasına katkıda bulunulacağı önerilmektedir.

Anahtar Kelimeler: Tarihsel Cephe, Görsel yapım, 3D Projeksiyon Haritalama, Sanal Facadism

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Thanks must also be addressed to the Architecture Department at EMU University, who not only educated me in my undergraduate years, but inspired and assisted with this thesis. The greatest thanks must go to my family. They have only ever supported whatever it is I attempt, including this out of the ordinary project for a Master's Degree in Architecture.

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Chapter 1

INTRODUCTION

Facade, as the outer skin of a building, has the capacity to impose specific qualities on buildings through utilizing different materials and various designing methods. It is an undeniable fact that facade plays a pivotal role in the impression and judgment of a person in terms of operation, identity and visual efficacy (Daab, 2013). Today, buildings are exposing a new face to the city and outline a new phenomenon for the citizens which in fact provides an outfit for the city as a living creature adopting with the cutting edge technology which are of paramount significance in our life style. Such changes have been more drastic by the advent of new materials such as glass, stones, certain metals and alloys, lighting and new generations of lamp bulbs (Smith, 2003). These days, facade, as a medium, has been a controversial issue. That is to say, media architecture is one of the most important driving forces to convert our perception regarding the world around us, leading to a link among architecture, digital space and public space. By media architecture, a building can convey a message which not only seems to be applicable for certain people, but also for universal (Tscherteu, 2008). Implementation of video projection has paved the way for media architecture as a novel tool which has created a channel of communication between urban environment and citizens. The history of video projection dates back to the year 1840. Lighting on a municipal monument in the public was the first use of Electric Arch light for beautifying public objects. In addition, video projection presentation was used in a memorial in the US (Bordonaro, 2006). During that time the needed equipment for such a thing were not of the size today and such devices for illustrating a picture using panorama technology were obviously massive and required many horses and wagons to transport them and its preparation attracted the public eye. In 1866, in order to encourage people to participate in the elections, the campaign was done by putting the questions on big screens by a video projection which made a novel notion in people. The exhibition of people's exhilaration could be seen in their cheering (Krautsack, 2011). By advances in technology, projecting pictures on large screens developed in quality and today the cutting edge technology projection tools can project pictures on three dimensional objects of high quality. It is even possible to visualize a dynamic 3-D object in the air not requiring any screens. Simulation, animation and dynamic video projection have developed considerably in the world today. All of these came to be possible through huge advances in computers, cameras, video projections, internet, printers, scanners and chips which have all established the basis of digital art and made its progress extremely quick. This has resulted in high quality works of digital art and quick broadcasting which seem really unbelievable (Saglamtimur, 2010). Video projection mapping is one of the newest types of projections which is capable of making a screen three or two dimensional for projecting a dynamic video regardless of being two or three dimensional in origin (Dalsgaard, 2011). Implementation of this in urban environment and also on facades at night can create an unimaginable impression on the perception of citizens. So far, such tools have had efficient applications in fashion shows, advertising and business, entertainment and recreation on buildings. Based on what Meunier 2011 says, companies which are always in progress of utilizing the cutting edge technology for providing their goods to the public take the 3-D phenomenon as a hot topic into account leading to a challenging competence in business (Ekim, 2011). As an illustration, Samsung was the pioneer in this regard which portrayed a new facade on a historical building, Beurs van Berlage in Amesterdam, for introducing a 3D projection mapping device for advertising purposes. As shown in Figures 1, in this show the building was split into two and the rest of the building was collapsed and the interior part of the building which was filled with water emptied and streamed into an imaginary jungle which were all virtual yet seeming realistic to one's eyes and at the end the 3D LED TV was emerged and was introduced to the market (Meunier, 2011).

Figure 1: Samsung 3D projection in Amsterdam, (Meunier, 2011)

As it was said earlier, Video Projection Mapping is not just a means of advertising. It is also on the way to create entertainment and public show in the society. Although, recently, designers pay attention to the identity and history of the place and take into account the link between building and the surrounding environment, this new piece of technology, video projection mapping, has not yet been utilized to improve the historical value of the building. Based on the aforementioned descriptions, this research is aiming to reconstruct the facade of the historical buildings by projecting the picture of their restored version. This can help to connect historical spaces which have historical contexts to new buildings at night time. By doing so, an integration can be made between the new part of the city with the older regions possessing a historical context. According to Smith (2013), the first implementation of facadism was a bank which was reformed to Melbourn University by utilizing facadism (Figure 2). The practice of facadism tries to preserve historical facade, it could both revive the building for a totally applicable function while the historical image of it remained intact for the citizens.

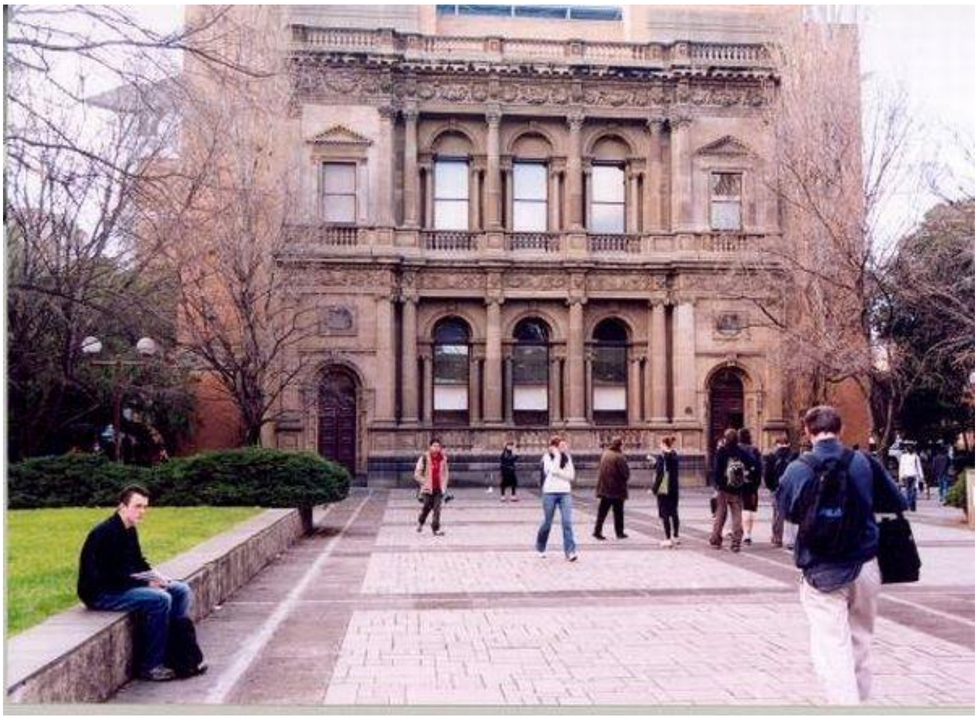

Figure 2: University of Melbourne in back side of old Commerce building (Smith, 2013)

By taking all the aforementioned into consideration, there can be an integration established between facadism and using video projection mapping on the historical facade in order to preserve the historical legacy of the building. This phenomenon can be termed as Virtual Facadism. In this research, restoring the historical face of the building by use of light projection is in question. In such a practice, making a link among form, environment and facade can turn to be plausible and audiences can experience different facade types in certain eras.

1.1 Significance of the Study

This study is significant for the reason that it will provide a guideline to reconstruction of historical facade which is an amalgamation of various methods driven from different researches. The current guideline elaborates on the application of 3D projection mapping for reconstructing the historical facades and whether an architect is capable of utilizing this technology to improve the view of historical facades at night and to integrate the fields of reconstruction, art, architecture and technology. Thus, the results of this study will not only be to the benefits of the students, and the teachers of art and architecture but also to all who are interested even in other majors such as art, reconstruct, media art, fashion or public design.

In addition, this study tries to examine a new visual technology for the facade of historical buildings and gives a new approach for using media facade on buildings that are valuable and needed to be preserved. In addition, this technology can change the public perceptions and it can make historical buildings more notable for visitors and they will be able to distinguish these places from others as a historical place. These dynamic facades can create visual attraction in public spaces and can relate the buildings to their historical and cultural background, which seems to be best preserved by the new methods of digital reconstruction.

Furthermore, this study will serve as a theoretical model for the reconstruction of the historical facades which are not practically reconstructable. In fact, the researchers and reconstructors, both, can benefit the guidelines proposed in the present research to revive the historical sites with less cost and higher accuracy.

In sum, the driving forces behind the application of 3D projection mapping on historical facades as a leading factor to reconstruct the historical facades are:

- To improve the meaning of historical places based on the contemporary life style of the time by means of the cutting edge technology.
- To create cost effective diverse views at nights on a certain building.
- To visualize the missing parts of a vandalized building.
- To revive the facade of a historical building in night time.
- To notify the architects about the application of the new designing material in lighting historical facades.
- To broaden the horizon in historical facade reconstruction by means of digital technology.

1.2 Statement of the Problem

The facade of the historical buildings changes over time due to some sudden changes such as earthquakes, flows, or other gradual changes such as erosion. Having a record of the visual presentation of the facade can reserve the buildings. In addition, presenting the reconstructed images through high-tech video projectors on the facades, especially at nights can illustrate a vivid view of the static buildings. In fact, in some cases, it would be impossible to reconstruct the site, or the reconstruction can increase the risk of damage during the process. And it is in these cases that the use of 3D video projection technology can be utilized as an effective method for solving such common problems in the field.

Moreover, nowadays, no one can deny the great impact of lighting in absorbing the tourists to the historical sites, especially at nights when the lighting can best present its outstanding qualities in attracting the audience. Such a situation, make the architect able to add more options to the previous lightings, such as 3D visual mapping technology. However, the later provides a 3D visual facade to the reconstruction of historical buildings. To the same fashion, reaching professional exhibition on the facades by digital technology can also improve lighting of buildings, as well.

1.3 Research Questions

As it was mentioned earlier, 3D projection mapping presents various ways for the architects to be able to integrate technology with history and to provide some solutions for the present reconstructive problems in the field. As a result, the researcher, in the present study, seeks to provide a guideline for three-dimensional reconstruction of historical facade through 3D video projection mapping and **investigate the exhibition capabilities of 3D video projection mapping** on historical facades.

The question arises here would be "**what can be an appropriate guideline in the implication of the 3D projection mapping for reconstruction purposes?"** What is the role of video projection mapping in the appearance of the historical buildings? Does video projection mapping work affect the perception of visitors and tourists in night time? Can such instruments be used as an advance lighting tool in historical facade?

1.4 Limitations and Delimitations

Visual reconstruction of historical facade by 3D projection mapping is a new trend in the field of architecture and this technology has never been used for the purpose of reconstruction of historical buildings so far, and no specific example can be provided for clarification. As a result, the researcher has tried to go through the process step-by-step and in details to provide a practical guideline for those who are interested in the integration of technology in the art of reconstruction. Yet, the guidelines suggested in the present paper are based on the authors' personal experience and knowledge. There may exist some other innovative and new techniques and models used for similar purposes that the author has no knowledge about.

1.5 Research Methodology and the Setting of the Study

The main part of this research is a final guideline proposed by the researcher which is designed based on the gathered information from the previous research in literature review. In order to establish reliable results, a qualitative-quantitative data gathering procedure was applied, containing a questionnaire focusing on the effectiveness of the capability of 3D projection mapping in artistic exhibitions, and an observation of a New Year ceremony in Siena, Italy. In fact, the researcher combined the results of the previous research and the present works, done in the field, as well as the conclusions gathered from the observations and the questionnaire, to come up with a new guideline which enables different groups of people from various artistic fields to use the technology in an appropriate way. The main purpose of the proposed guideline is reconstructing the historical facades virtually. The guideline is an integration of some methods of traditional reconstruction which is usually used for reconstruction purposes, such as research of historical facade, documenting historical objects, measuring of the historical building and redrawing a plan, section and evaluation of historical building, computer modeling technology to create 2D or 3D images of historical building by different software, and projecting three dimensional images on 3D objects. The framework can be summarized in the following diagram (Figure 3).

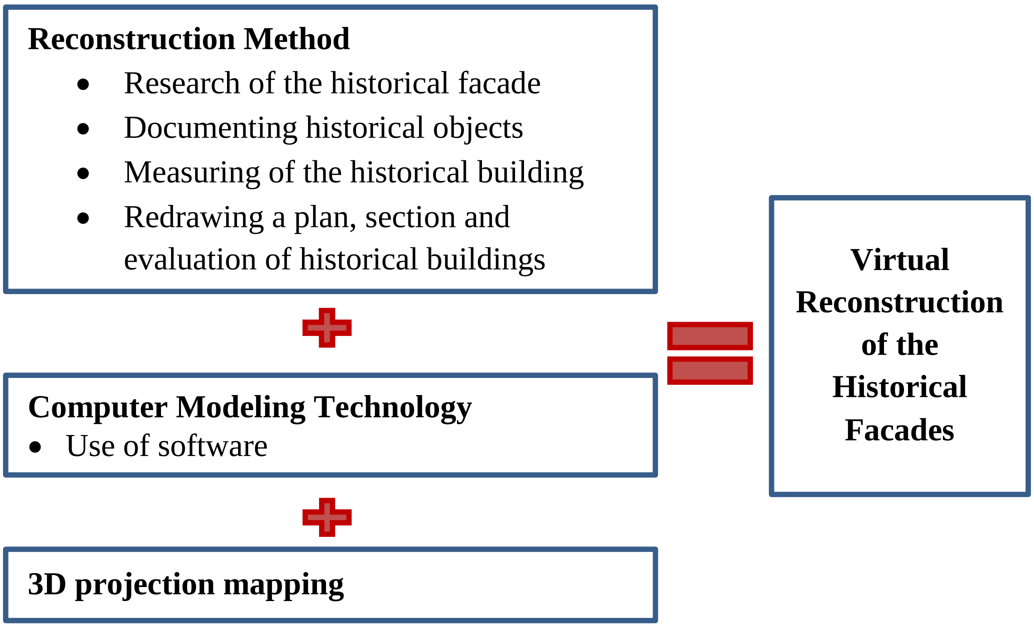

Figure 3: General view of the sources to obtain a guideline

Apart from the use of the implications and results of the previous research in the field, through investigating the exhibition capabilities of 3D video projection mapping on historical facades, the researcher observed a New Year ceremony which is held in Siena, Italy. It is worth noting that the video projection mapping exhibition in the historical center of Siena, Pizza del campo, is held annually since 2010 and the researcher has observed the ceremony in 2013. Details of the observation will be discussed in Chapter 3. And finally, a questionnaire was administered among 30 local people of Siena who has participated in all the exhibitions held in Pizza Del Campo since 2010 in order to obtain the general perspective of the public toward such an innovation. The quantitative analysis of the answers will also be reported in

Chapter 3 of this study. The steps have been followed to show the effectiveness of the proposed guideline and highlighting the role of 3D projection mapping in absorbing the audience. To provide a comprehensible image of this study and the whole process of the project, a chart has been illustrated (Figure 4).

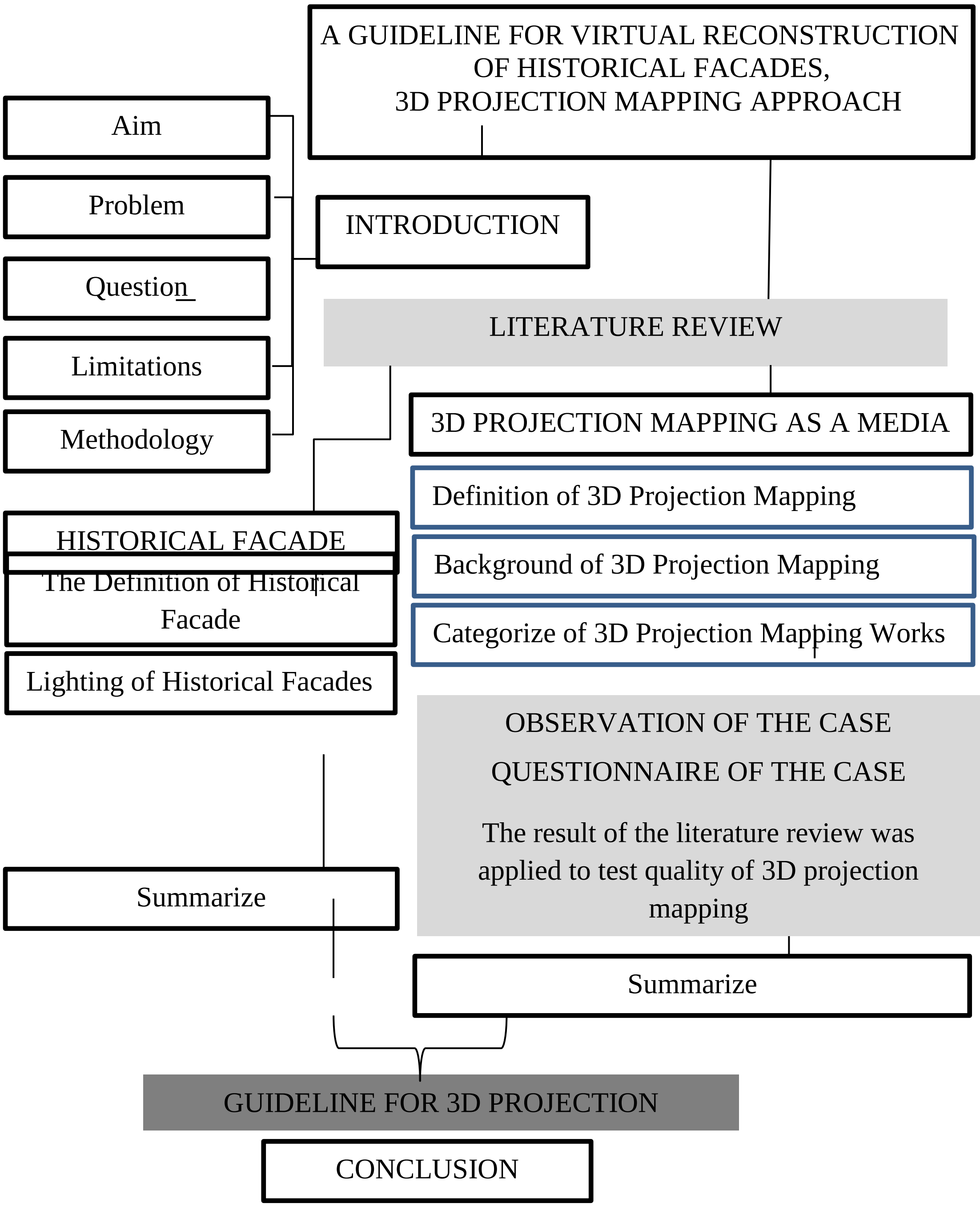

Figure 4: General view of this study

Chapter 2

HISTORICAL FACADE

The present chapter is allocated to definition of facade in historical context and historical building. This section discusses effects of lighting on the facade of the historical building at night time and view of the historical context with lighting and new technology.

2.1 The Definition of Historical Facade

Historical facade which is generally exterior side of a historical building, as a significant part, tells us about cultural and architectural history of buildings. Facade has a magical power to absorb people to the historical building. Preserve a historical facade which has the main role of city's view, is a direct influence on urban identity (Bräuer, 2008). Loss of a historical facade affects not only the particular structure or site that is destroyed but also an entire community. The loss of facade in historical context undermines a community's ability to utilize its historic fabric to attract and retain business, generate tourism, and create an attractive place for people. A historical building provides opportunities for economic and cultural vitality. Exterior facades of historical buildings convey a part of the identity of a society and are associated with its culture and values. Preserving historical and cultural values of each society requires due attention of artists and architects. Sensitivity and preciousness of historical facades might make their preservation more demanding and challenging. Therefore, they need to deploy various techniques and approaches in an attempt to preserve the values and identity of a certain area, improve the historical spaces using contemporary technology, and to create harmony between the historical context and other urban spaces (Meunier, 2011). Through the transformation from industrial era to the age of information, most fields have been affected and shifted to different and new shapes of realities. The influence of this transformation on the field of reconstruction of historical building is undeniable. The age of information and electronic has specifically affected the two concepts of image and form in architecture. This impact seems to be more visible on the image and form of historical buildings and their surrounding environments particularly at nights (Smith J. , 2003). Therefore, knowing the qualities of artificial lighting specifically on the facade of historical buildings would be required. One of the tools to provide artificial lighting is ‘Video Projection Mapping’ which can be deployed for the sake of reconstruction of historical facades. In order to understand how this tool works, lighting on the facade of historical buildings, historical contexts, and different types of lighting will be elaborated in the following sections.

2.2 Lighting of Historical Facades

A modern society can be recognized by the degree of lighting deployment in the outdoor environment. Use of artificial lighting particularly in historical context can contribute to the colonization of time by human beings. Nowadays, metropolitan cities worldwide are trying to compete and take over each other in providing better light effects on historical buildings and appearing them more attractive at nights to absorb tourists and visitors (Erco, 2013).

Light and color are two fundamental factors perceived by human beings. Lighting of monuments and historical buildings plays a critical role in generating urban lighting conditions. Scheme of lighting can be utilized to stress the identity and hierarchy of masterpieces while lighting plan of a city can be designed through zoning of the historical places as located on a light map. A mood for the image of the city can be set by using lighting and color scheme. Exterior lighting provides scope for more creativity and the privilege to design color and light on a scale that extends from distant view of a town to the close detail of the building facade (Kutu, 2012).

A revived interest in use of light in the historical contexts has been raised in the last few years. This can be attributed to alteration in life style and the way of living in public spaces overnight. This interest for the public, initiated in the 1980s, was the foundation of architectural and social studies and addressing lighting in urban studies (Kutu, 2012) . Bordonaro (2006) states that lighting and a positive nighttime image of the city can contribute to enhancing communication, aesthetical growth, visual comfort, social interaction, security, and safety.

In order to perceive, experience, and interpret spaces, light is required. Talking from an architectural point of view, light can be referred to as the fourth dimension, lighting can significantly contribute to the field of architecture as far as cultural and historical activities are concerned (Manovich, 2001). In addition, in a city, the night impression including both feelings of security and attractiveness is extensively influenced by lighting. Since the urban night image is created by a variety of illuminated urban elements (streets, buildings, bridges, parks, historical buildings and monuments, etc.) (CIE, 2008), developing coordination is necessary in order to achieve a harmonious urban nightscape especially with historical context and contemporary parts. Two types of coordination are necessary. The first should stress the hierarchy of the illuminated urban elements according to their significance (historical buildings and monument) and the second needs to provide harmony of street, ambient and architectural lighting. These tasks are best achieved through lighting master plans (Goulthorpe, 2003). Building illumination creates the possibility to emphasize those elements which are not noticed in daylight. Lighting can accentuate style elements, decorative details, reliefs and ornaments which possess historical, architectural or artistic values (Djokic, 2012). As to the focus of this study, illuminating facades of buildings can help the viewers have a better sense of their surroundings; because facades can communicate messages and are able to attract the attention of the observers.

To serve the above-mentioned purposes, lighting used to illuminate the facade of historical buildings at night is divided into five general types which can be deployed based on the lighting design. Figure 5 summarizes various kinds of lighting which can be used in historical facades. What is special in the application of video projection mapping is its capability of proposing all these lighting methods at once.

It can provide flexible, high quality artificial lighting which can be used for various designing purposes. Video projected mapped lightings on historical buildings are integration of different types of lightings. In other words, video projection mapping has one or a few commonalities with all types of lighting introduced before. For example, similar to conventional external lighting, light is distributed and projected on to the building from a distance. Video projection mapping has the ability to highlight details and create a novel view like detail lighting. It has also the ability to produce colored patterns and movements as displayed in dynamic lighting. Similar to communicative and emotional lightings it can communicate with visitors and convey a certain message or value offering a variety of colors and patterns, respectively. Meanwhile, because video projection mapping exploits the latest technologies and modern means of control, the images it creates are significantly better in terms of quality in comparison with more traditional and conventional types of lighting. Creating light at nights by using video projection mapping has gained importance, because this technique introduces and magnifies a historical event, object or eminent figure (Dalsgaard, 2011).

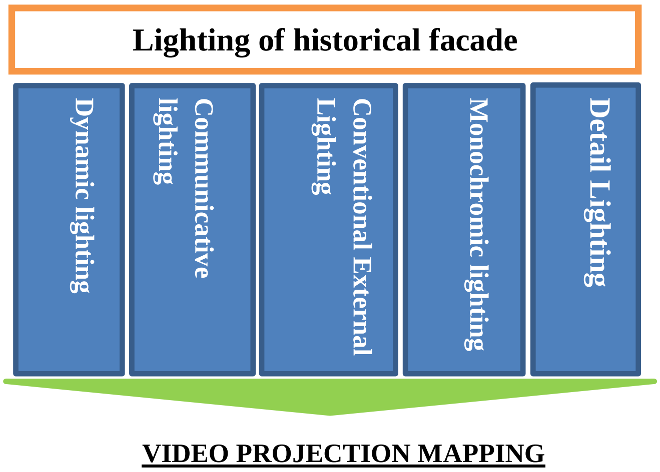

Figure 5: Category of historical lighting

2.2.1 Detail Lighting

Detail lighting emphasizes architecture, materials being used in the building, and the lighting effects. This type of lighting does not alter the character and qualities of the building. The elements of facade are highlighted and there is an emphasis on its natural structures. Small lighting appliances are fixed onto the facade to light certain details. Detail lighting can be referred to as lighting on the facade's elements which functions in a range of forms from mini-floodlights to highly efficient light-emitting diode (LED) linear fittings. Since the fixtures are placed on the facade, it should be guaranteed that the facade and fabric are protected from damage. The major aim of detail lighting is to create a different view of a particular building overnight (Zumtobel, 2010).

2.2.2 Monochromic Lighting

Monochromic lighting is the use of light to shape or to transform architecture instead of adding ornamental or fictitious details to it. This type of lighting, particularly at night, can add a novel, fresh and different character to a plain structure so that the observers can perceive the object more emotionally. Especially for surfaces which are neutral in color (e.g. beige, light gray, white, etc.), monochromic lighting is one of the most appropriate lighting types. As shown in Figures 6 and 7 (two eminent examples from Greece), this type of lighting, if installed properly, can be very effective. It is quite obvious in both pictures that the applied colors in form of monochromic light not only did not degrade the white facade, but as Djokic (2012) words they stressed important architectural elements.

Figure 6: Technopolis Center, Greece, (Djokic, 2012)

Figure 7: Lighthouse, Ahea, Greece (Djokic, 2012)

2.2.3 Conventional External Lighting

By using projectors with large-wattage, a large amount of light can be produced in conventional external lighting. In order to distribute light perfectly, lighting apparatus should be placed far from the building to make the architectural qualities and features appear as they look like in daylight (Heritage, 2007). An example of conventional external lighting is given in Figure 8.


Figure 8: Wash light Houston City Hall, (Heritage, 2007)

2.2.4 Communicative Lighting

Through the use of communicative lighting, not only the appearance of the facade is highlighted but also some kind of information is conveyed. Communicative lighting provides the opportunity to present massages and values in the form of texts, animations or images. Such lighting concepts are compatible with the fast pace of the world today and make the best use of the potential of the communities that live in such a world. By exploiting communicative lighting, companies, factories, etc. can communicate with people even at night (TscherteU, 2008).

2.2.5 Dynamic Lighting

In order to be able to create colored light, patterns in move or images, dynamic lighting uses fixtures which are known as theater-like. Uses of this type of lighting are limited to special events and occasions and on the buildings which are not ornamented and look plain (Heritage, 2007). Changes in color and/or intensity of light are the tricks used to result in dynamic lighting. However, this type of lighting is applicable in particular temporary regime aiming a special effect (Williams, 1999). Thanks to technology any surface can be used as a screenplay on which light moves, its intensity and color change rhythmically and altogether result in a particular visual performance. Even if willing, text messages, pictures or color plays can be displayed by using an electronic system run by a computer program. All these abilities have made dynamic lighting popular especially for city landmarks, such as the Eiffel Tower in Paris (Cie, 2007). On the occasion of its 120^{th} years in 2009, 400 LED RGB luminaries were installed on the Eiffel Tower giving a memorable light show (Figure 9).

Figure 9: LED illumination of the Eiffel Tower -2009, (CIE, 2008)

The dynamic lighting method gave a large number of possibilities of 17 minute light shows displayed 4 times each evening during a 10 day period before the New Year's Eve. However, the light shows were based on a preplanned scenario: starting by a glitter show, the building process of the Tower's structure was described through a consecutive bottom-up activation of luminaries. Meanwhile, some complementary light showers were hired in order to add to the overall presentation. However, it deserves to highlight that on historical monuments, permanent dynamic light shows with quick changes in color and intensity of light should be avoided because they may annoy their visitors or even people from a rather far distance. In this respect, bridges are better choices if dynamic light shows are displayed with attention to their duration and frequency (Djokic, 2012). In light performance projects in which it is aimed to attract the attention of viewers and impress them according to a specific scenario, an additional combination with sound may also be used (Williams, 1999).

2.3 Significance of Lighting on Historical Building

Today, lighting on historical buildings seems to be more significant compared to other public places. External lighting in historical contexts gains its criticality through serving the following objectives:

1. Creating **harmony between meaning and identity of the place**, which is considered a top priority in historical contexts.
2. Creating a light space which **highlights historical buildings** and their main composing **elements** through appropriate selection of the color of the light, and intensity and angle of radiation of the light, although creating a space which attracts and invites the audience and **emphasizes the aesthetic elements** of the place through developing light in various linear, extended, or spot-like forms (Figure 10, 11, 12).

Figure 10: Spot-like forms, (Kutu, 2012)

Figure 12: Extended lighting, (Bordonaro, 2006)

Figure 11: Outdoor linear lighting, (Atkins, 1991)

3. Promoting the **quality of observation** and experience of a certain site against the background of building at night.
4. Adding a new face to the historical building at night which, in turn, enhances the historical and **social values of the building**.

5. Contributing to the economy by promoting night use of historical places. (Atkins, 1991).

It should be noted that, to achieve the above mentioned objectives both technical and aesthetic aspects need to be taken into consideration. When all the required factors and elements are appropriately integrated into each other to create a well-designed scheme and the equipment is chosen correctly, soul can be returned to a historical place. Therefore, architecture can be extended by external lighting which is able to complement the shape of a certain structure, color, and form and to improve the quality of view (Heritage, 2007).

Most monuments and historical buildings are outstanding manifests of an intricate blend of engineering and architecture. To enjoy these feats even at nights, delicate schemes of external lightings can be used. Lighting concepts which are harmonious with architectural qualities and features are required for lighting facades of historical buildings. For example, columns, friezes, porticoes, and three sections of facades, that are, the portal and two side wings need to be considered in the concept of lighting (Erco, 2013). Therefore, designing the light to be applied on buildings can bring them to the center of attention of the viewers and is able to create a relation between the buildings and the whole context they are located in. Consequently, it will help the audience gain a better understanding of the historical space they are exposed to (CIE, 2008).

Figure 13 provides an outline of the highlights of the definitions of historical facades and the related lighting techniques.

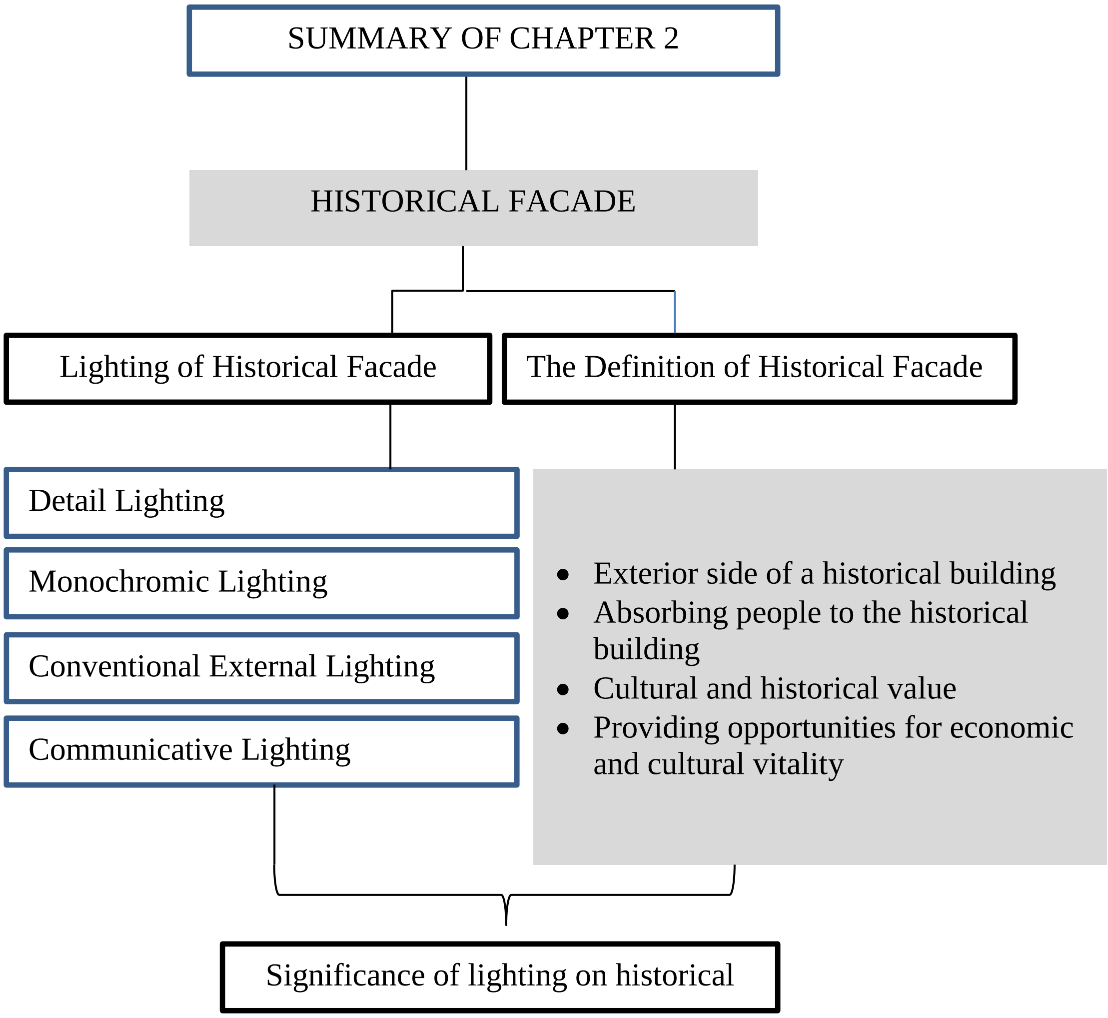

Figure 13: General view of historical facade

Chapter 3

3D PROJECTION MAPPING AS A MEDIA

This chapter is composed of the definition of 3D projection mapping technology and its various applications which are divided to two categories of “artistic or entertainment” and “advertising”. As it is easily recognized from the title in “artistic or entertainment”, the researcher seeks to investigate the application of 3D projection mapping for entertainment purposes, which is of great importance in public services. The discussion is followed by discussions on the effectiveness of 3D projection mapping in the world of “advertisement” and the flexible capacity which is provided by such a system for advertisement objectives. Finally, the researcher has come up with a new perspective in the application of 3D projection mapping, i.e. “virtual reconstruction” which is discussed later in the chapter.

3.1 Definition of 3D Projection Mapping

One of the latest techniques in video projection is ‘video projection mapping’ which has the ability to create a dynamic video show on any surface. This technique blends visual and audio elements and generates an audio-visual narrative. Projection mapping is commonly used in events such as concerts, fashion shows, and theatrical performances. Another application of video projection mapping is in the field of architecture where the system is used to attract a larger number of audiences through image display on historical structures in public spaces (Ekim, 2011).

Video mapping can be the light and sound animations projected on facades. 3D effects make such realistic light illusions that the visitors feel that the building is moving, its structure is falling apart, or columns are dancing, etc. such imaginative programs can be shown at a certain time or in special occasions (Djokic, 2012). A number of techniques should be taken into consideration in order to produce an attractive exhibition on the facade through this approach. If viewer's perception of an object from a distance is intended, enough contrast between the surroundings and the luminance should be made. Moreover, according to the darkness/brightness of the environment, degree of illumination and accentuation of buildings and/or objects should be adjusted.

Moreover, the adaptability and flexibility provided by the use of video projection mapping make it an instrument for architectural purposes, whether the urban architecture, where video projection mapping can be used in parks, public places and shopping centers, or in historical buildings and historical facades which are precious and reveal the essence and origin of any area illustrating the soul of past. However, though it is claimed that these projections on buildings are 'architectural', in reality, the interaction between architecture and projection is often ignored and the facade of buildings is merely used as a projection screen (Sahin, 2013). Recently, the appropriate designs and deploying media tools have paved the way to link historical contexts and buildings with modern urban spaces without causing any damage (Binay, 2012).

3.2 Background of 3D Projection Mapping

According to Rossell (1998) light projection has been interesting to people even in the ancient world. For instance, in the ancient Greek theatre, spatial illusions were created on the elements of the flat stage by the attempt of stage designers. This need necessitated the conduct of research on light projection and perspective issues. In the 15th century Filippo Brunelleschi rediscovered these ideas with linear perspective, which was pursued by the production of the ‘magic lantern’ in late 16th century (Rossell, 1998). Magic lantern was mainly used by magicians to animate objects or to make the audience believe that they are able to bring the dead back to life. Koltsova (2012), proposes that there are similarities between archtectural projections and ancient magic lanterns contending that they are far different as regards perception, scale, and technology.

In the beginning years of the 20th century, a number of artists such as László Moholo-Nagy started exploring the plausibility of using artificial light in photography, for light sculptures as well as stage design (Kuball, 2012). The findings of those experiments and explorations can be regarded as prototypes of stage projections which were performed in late 20^{th} century (e.g., Karajan’s Berlin Philharmonic Orchestra, Pink Floyd).The popularity of architectural projection can be explained by the usage of artificial light in places which are exposed to a little amount of sunlight throughout the year. Culturally speaking, communities such as northern Europeans whose culture oroginates from the woods, have had the tradition of bringing light into dark and cold nights throughout winter; for example, lighting Christmas trees, or Scandinavia’s St. Lucy’s Day. Any culture generates its own symbolic meaning and association for light, shadow, sun, and fire. Hence, artists develop various affinities towards light, which can be based on South-east Asian or Chinese shadow plays or other symbols and metaphors. Similarly, the audience can associate with artificial light exposed to in public spaces in mnay different ways. Christmas lights are one possibility. As shown in Figures 14, Neon lights, best known in Las Vegas, are another association. The city itself changes into a giant sculpture ade of light at night and fascinates the viewers when is seen from the street level, from the top of a hill, or from an airplane. People are used to seeing illuminated buildings at nights particularly in urban spaces. Therefore, an illuminated building like a church does not fascinate them any longer; but they need to see extraordinary illuminations wich are beyond the routine normsto get excited. As an example, the impressive combinations of natural and artificial lighting by James Turrell can be mentioned (Shaw, 2013).

Figure 14: Neon light in Las Vegas, (Shaw, 2013)

In the same vein, Paul Houdin-Robert who introduced the concept of ‘son et lumière’ for the first time and conducted it in the year 1952 at Châ-teau de Chambordin France, should be known as one of the pioneers of large scale projections in architecture (Dupont, 2013). The aim of the project was to combine sound and light to narrate the history of a certain location with a magical atmosphere. The projections were exhibited mainly in France, and some were shown in India and Rome in the 1950s and 1960s. The exhibitions inspired many concert stage designers and projection artists in the 1990s such as the Paris London based The Projection Studio. In the last 20 years, the digital technology, particularly computer graphics improved , the digital projection hardware became more available and techniques of interaction altered the means artists used to explore the relationships of time, space, architecture, and culture. A significant work belongs to Jeffrey Shaw (1991),'The Legible City', which was conducted in 1988 . The work enabled the audience to ride on a stationery bicycle to travel in a virtual 3D world, in which the streets were based on a real city (Manhattan, Amsterdam, Karlsruhe). The streets were represented by 3D letters and words that allowed the user follow narrative threads (Figure 15).

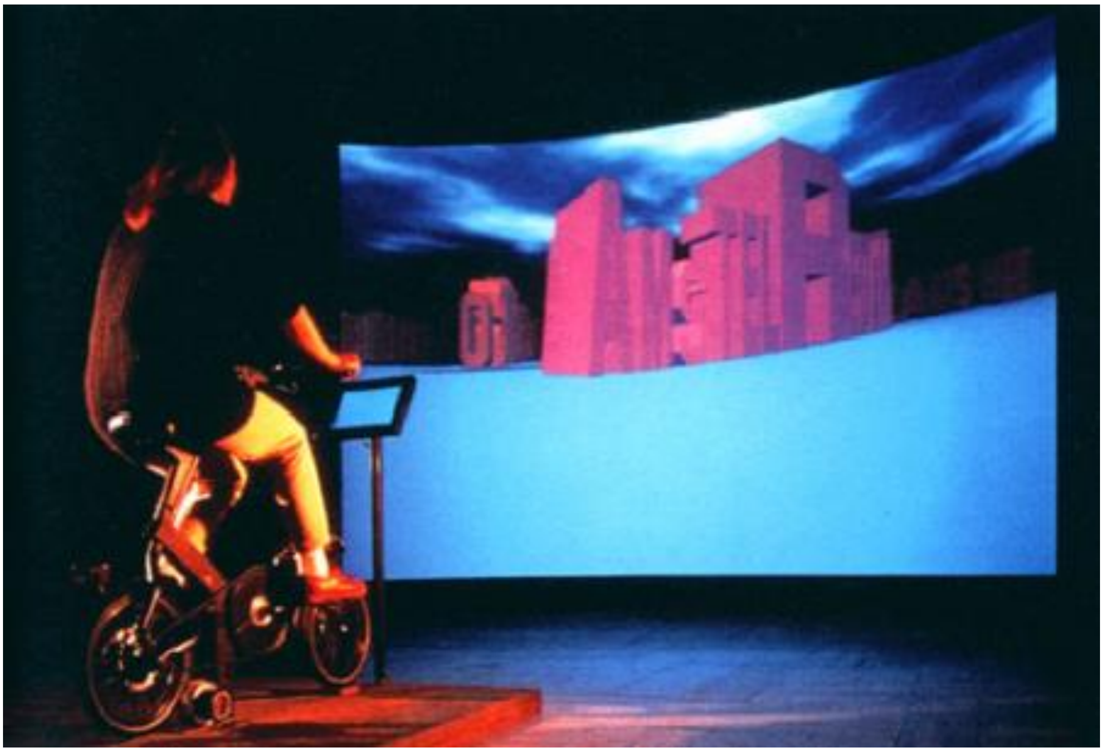

Figure 15 : The Legible City, Jeffrey Shaw, (Raskar, 2005)

Another influential work is ‘Displaced Emperorsby Rafael Lozano-Hemmer’, which was presented at ‘Ars Electronica’ in the year1997, in Linz. Through use of wireless 3D sensors, the visitors were able to bring to view the interior spaces of the Habsburg residence in Mexico City , Castillo de Chapultepec (Figure 16).

Figure 16: Emperadores Desplazados, (Raskar, 2005)

These images were projected on the facade of the Linz Hapsburg castle. With its historical references, it thereby “departs from the supposition that cultural property is cultural poverty. As an architectural Mise en abyme, the project supports the idea of perpetration of culture instead of calls for its vampiric preservation” (Hemmer, 1997). In 1998, Raskar et al. devised ‘Spatially Augmented Reality’ term, which deployed geometric mapping, computer graphics, and projectors to produce a type of increased reality which didn’t need virtual reality helmets (Raskar, 2005). In another case, Pablo Valbuena (2007) performed an application in art with his ‘Augmented Sculpture’ v1.2, which was also exhibited at Ars Electronica (Hontoria, 2014)(Figure 17). Since then, techniques of spatial augmented reality became more prevalent, with remarkble artists’ labels like the French-British ANTIVJ, Germany’s URBAN-SCREEN ,or Australia’s The Electric Canvas (Rossa, 2010). Meanwhile, the techniques were promoted for marketing purposes such as PLAYMIND’s projection for Microsoft. Some others were investigating the possibilities and potentials of mobile projectors like Blue-BlastMedia's Target Velocity Projections (Figure 18). In these projections the content was not mapped onto the building facades, but rather animated symbols had the ability to 'run' on buildings (Davis, 2014).

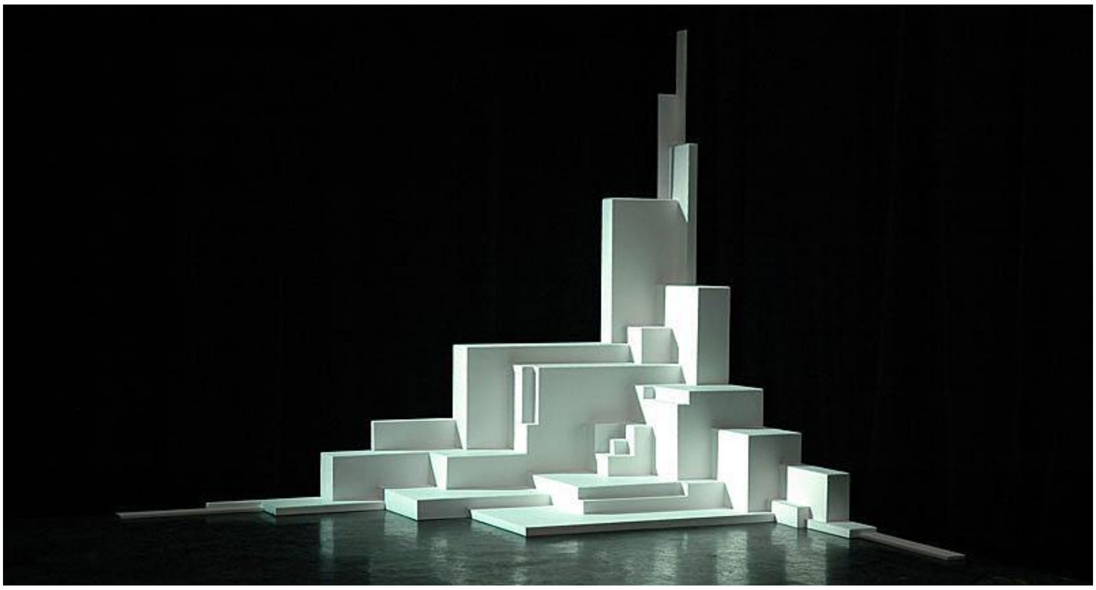

Figure 17: 'Augmented Sculpture' v1.2, Pablo Valbuena, (Hontoria, 2014)

Figure 18: Velocity projections, Reebok, Lady Foot Locker, (Vimeo, 2014)

The emergence of artists and art collectives, many of them using a do-it-yourself approach, realizing projections in public urban space also indicates a close relationship to the many forms of urban art and street art, as often some ‘guerilla activities’ were involved. While sprayed graffiti and tags are used to communicate visually with other subcultural groups, 20 public projections absorbed a great number of audience, most probably because they were operating on a larger scale. In 2007, the Graffiti Research Lab established with laser. Tag an explicit link between tagging and projections by combining projectors and laser pointers to tag buildings at large scale.

Meanwhile, in the commercial ara, companies attempted to take advantage of the technical possibilities to extend the projections’ scales. In 2008, a projector manufacturer named ‘Christie’ employed 27 projectors for a building in Quebec (Figure 19) to generate an oversized screen with a width of 600 meters and height of 30 meters (Lepage, 2008).

Figure 19: Quebec city's 400th anniversary relate to its History, (Lepage, 2008)

3.3 Categorizing of 3D Projection Mapping as a Media Element

Nowadays, Media elements are widely found in urban places and building facades in various forms with different applications. In fact, a facade can represent a skin to inhabitants and, structurally speaking, at the same time function as the urban fabric face and operate as a vehicle for message delivery between the interior and exterior, between the public space and the building. As a result, different forms of outdoor screen such as large screens, media city buildings, urban public arts, mood-walls, and body movies, which are to be discussed later in this section, have been considered as an integral component of public places. In addition, the growth of media in the urban places and its widespread applications has led to the existence of a technical field in the architecture called "mediatecture". Meditecture is applied in two forms where some elements are installed and some elements are projected on the facade of the building. Due to the fact that the focus of the present study is on video projection mapping as an element which is used in "projection displays", the researcher has discussed the two applications of projection displays in "advertisement exhibitions" and "artistic and entertainment exhibitions".

3.3.1 Outdoor Screen

By the introduction of television to the market, families debates initiated over the subject whether this invention should be integrated into family homes or not. Consequently, it found a spectacular place in homes not only as a media platform but also as a furniture item. For its specific technical mission, domestic sphere was primarily targeted. While television was expanding its role and impact on the private life of its users, its existence also had a broader consequence: as a key manifestation of the public sphere, structure of public culture was then under its continuous checks. This was the trigger for the introduction and growth of cable networks and satellite channels in the years 1970s (Spigel, 1992).

These advancements were the fruits of the broadcast paradigm dominant since 1950s in which larger numbers of audiences were accessed; however, their scope was limited to a specific city or region. What began to emerge, unevenly and with different levels of concentration and intensity, was the current proliferation of channels operating on national and global scales (Hilmes, 2002).

A second benchmark was the emergence of street TV screens. Although their emergence received less critical attention in the beginning, from mid 1990s more public or large screens are erected on streets, parks and public places all over the world. The modern (newer) large screens have evolved; in other words, they are far different from those emerged in mid-1970s (Cubitt, 2000).

The famous Spectacular Board, installed on the old New York Times building at One Times Square in 1976, was really a programmable electronic sign. Although it may seem rather ordinary today, it was the pioneer signage of its time. Using krypton shining bulbs, it could produce mono color graphics; however, its capacity in displaying different sorts of contents was the key to its uniqueness, turning it to a broadcast medium referred to as ‘signage pioneer’ by George Stonbely (Gray, 2000). Accordingly, a range of different advertisers and artists showed great interest in this signage; for example, in the mid-1980s, Jenny Holzer, exploited the Times Square’s screen to show texts from her famous series ‘Truisms’.

The other significant innovations in street TV technology were the Sony’s Jumbo Tron and Mitsubishi’s Diamond Vision in the mid-1980s. These screens benefitted a matrix of small Cathode Ray Tube (CRT) displays rather than using shining light bulbs. Though CRT large screens (e.g. Jambo Tren was 25 to 40 meters) were extremely costly to buy and to operate, because they were better in displaying full color videos as regards resolutions, they became popular among best sports complexes and crowded central city neighborhoods.

The third outstanding street screen model was the result of the rise of LED (light emitting diode) technology. LED screens introduced to the market as video displays in late 1990's soon occupied the market of large screens. In spite of their high prices, they offer daylight displays with higher versatility, lower operation and maintenance costs as well as more flexibility in terms of integration into buildings.

Many well-known streetscapes are dominated by LED screens nowadays. Manhattan's Times Square, where they display on significant buildings like Disney's Times Square Studios (1999) used by its ABC Television network, and Nasdaq's Market Site building at the northwest corner of Four Times Square are a few examples (Ranaulo, 2001).

Historically, the built environment has been based on centuries-old materials, construction techniques, and static functionality. This issue seems very valid in case of old buildings; their construction process, their materials and their architecture. Old (traditional) buildings follow an alloplastic mode of operation; they are static and determinate (Goulthorpe, 2003). However, recent (modern) buildings are the result of progress in building and construction technologies (Banham, 1984).

Advancements in built environment in 19^{th} and 20^{th} centuries led to a revolution in construction; new materials such as steel, glass and lightweight concrete were used as the main materials of construction, new infrastructures and complex systems such as air conditioning systems, central heating systems and elevators provided the possibility to inhabit in new environments and spaces.

Today's design tools, the reality of the built environment and working concepts are now transforming because of the advancements in digital design software as well as broadband media and network designs and production processes (Massumi, 2006). As Manovich (2006) claims, as a result of advanced technologies, modern built environments have a new feature; adaptability and interaction with their users.

Scaling up public displays has always been constrained by CRT technology. Initially, public displays were applied for commercial purposes such as broadcasting breaking news rather than research purposes. In 1928, the facade of the New York Times building was encircled by Motogram or "zipper" for displaying breaking news through utilizing light bulbs in a dot-matrix pattern. Airports, stadiums, bus and train stations soon employed the modern technology in public displays. More advanced low resolution media was used in the 1980s and 1990s for promotions and advertisements by large animated exhibitions. However, more recently digital signage benefitting from LCD and Plasma technologies became capable to display video streams with full size while minimizing power consumption. There should be no wonder why recently public displays have become research and commercial tools (Kostakos, 2013).

Now, designers of public spaces widely use modern communication ways and digital technology creations. As an example, projectors with large screens, which are connected by networks, have generated a new public communication system via multimedia. Growth of reliability in technology has made installations of digital displays to be used not only in shops and for entertainment purposes but also in gardens and museums. Nowadays, designers are able to combine light, digital sound, architecture, and virtual images to develop a different and new method of communication through which we are able to have novel urban experiences. Nowadays, screens can be seen everywhere outdoor; they even have been used as coats of architecture. Public spaces have been highly influenced by the wide use of digital equipment especially during the last two decades; global convergence is accelerated and regional differences are smoothed. Today, mobile media has a significant role in public space. Paul Virilio (2000) has introduced a new concept which implies transmitting information by means of buildings. Virilio perceives media building as an electronic church and contends that both of them spread information but differ in mode and speed of transmission. However, architectural experiences such as rose windows or frescoes cannot be created by electronic screens.

Now, it is possible for people to observe media buildings, recall the past and expect the future in urban public spaces. Moreover, the digital technology deployed in public spaces can create a particular sense in the place. Different types of cultural and social activities are effective means of keeping public spaces vital and alive. The outdoor screens can be exploited as boards to broadcast information, to display sports, movies, or concerts. It explains the concept “Society of The Spectacle” proposed by Guy Debord (2001), that individuals are only consumers of what has been created by others.

BBC, the famous Britain Broadcasting Corporation, conducted a research on “Society of the Spectacle” to recognize the ways of interaction between digital technology and public spaces. For their research some large screen TV projectors were installed in some cities in England to resuscitate public space. Results showed that the large screens worked. The network integrating events and activities enhanced the local culture, preserved the collective memory, and highlighted the place. In the meantime, digital technology raised the sense of place by offering new position identifiers (Shidan, 2010).

By developing digital technology in a space and through signage players the vocabulary of the space will be enlarged, communication circumstances will be varied, and urban landscape will be enriched. David Rokeby (1995) contends that digital aesthetics is not a static work of art but it creates relations. It develops social relations rather than an image or object. Multimedia billboards, information display installations, plasma screens, etc. have been used widely in public spaces and have affected the daily life of people in many aspects. Digital technology has created new expressions of public space by using the following tools and approaches: (Rokeby, 1995) Figure 20 illustrates the process of development of TV from interior to the facade of buildings and the examples which are discussed below.

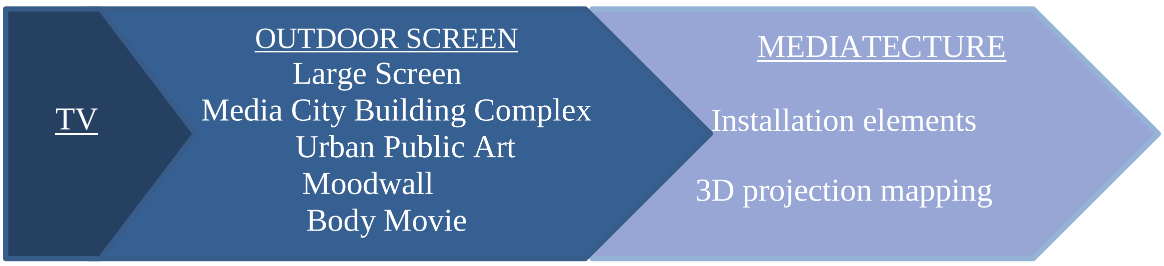

Figure 20: Process of media

- **Large Screen**

Large Screens have been frequently used recently as an element of media. By forming a space both real and virtual, they act as a stage for cultural performances as well as for communication (Figure 21). Although there is a pitfall in installing them, they may weaken the stability of architectural surfaces; they offer new opportunities for designing public space and creating new values (Tomitsch, 2006).

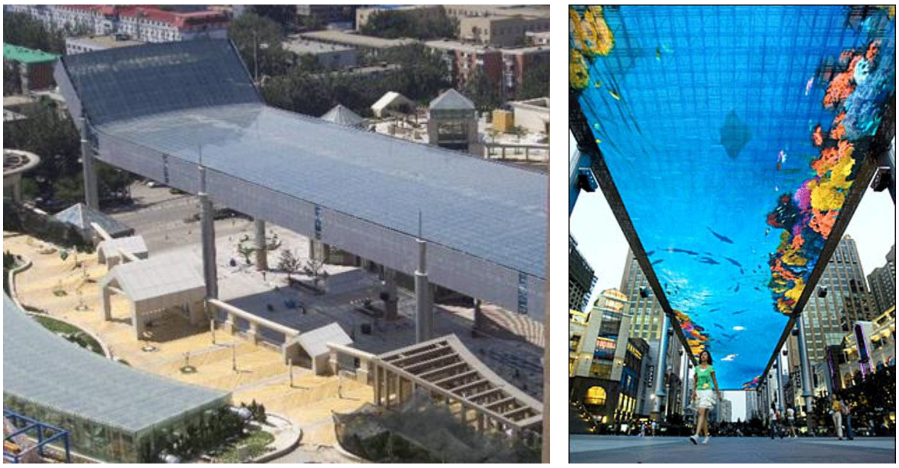

Figure 21: Large LED screen in Beijing, (Tomitsch, 2006)

- **Media City Building Complex**

Media city building complex presents new attainments in digital technology. The Fremont Street Experience in Las Vegas (Figure 22) provides people with visual and timely information through multimedia and projecting images on the aluminum ceiling at night (Naimark, 1999).

Figure 22: Fremont street - Las Vegas, (Naimark, 1999)

- **Urban Public Art**

Digital technology can also be utilized to serve the purposes of urban public art. In Chicago Millennium Park (Figure 23), the color screen of Crown Fountain displays 1,000 images of the citizens, and there is water spraying from the mouth. This funny installment brings energy to the park (Shidan, 2010).

Figure 23: Crown fountain, Millennium Park- day and night, (Shidan, 2010)

- **Moodwall**

Urban lost spaces can also be used more efficiently by using digital technology. One way is installing Moodwalls. As an example, a moodwall which is 25 meters in length and has interactive light installation and is composed of 2500 LEDs is located behind a semi-transparent ribbed wall of a tunnel built in a pedestrian in Amsterdam (Figure 24). It creates a sort of interaction with people passing from the tunnel through improving the atmosphere and creating feelings of happiness and safety (Shidan, 2010).

Figure 24: Moodwall, front view and left view, Amsterdam, (Shidan, 2010)

- **Body Movie**

Body Movie increases the interactivity between the viewers and public spaces. Large- size projector screens provide people with absorbing ways to participate, and further generates a balance between personal and group performance (Figure 25). Every single person plays a role in the performance and the public space is used efficiently.

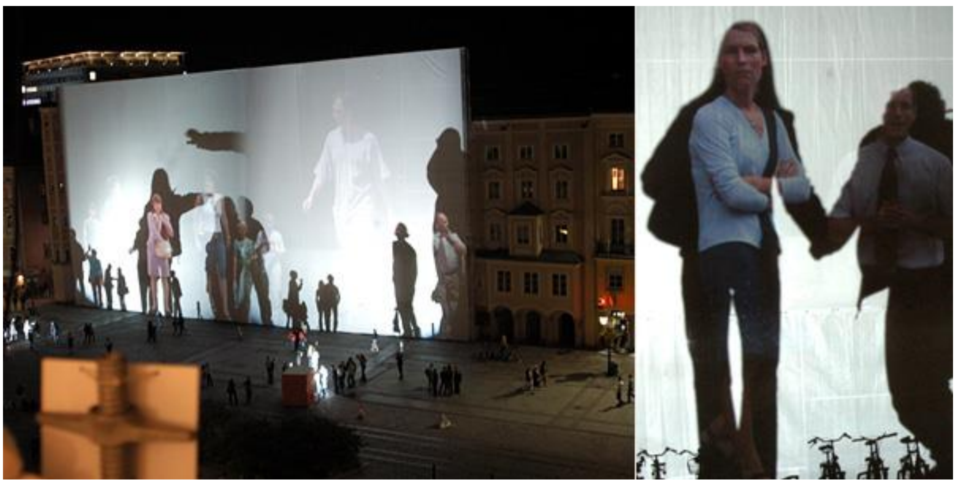

Figure 25: Body Movies by Rafael Lozano-Hemmer, (Ranaulo, 2001)

LED technology also supports a number of new products like the ‘media facade’ systems created by German-based company Ag4 mediatecture. They allow a transparent surface to cover the entire building. It should be noted that the occupants looking outside see the surface as transparent, but it underpins large-scale video images when is viewed from the street. The great increase in the production of LED screens has made architecture move towards a new role as what is termed by Paul Virilio as ‘media buildings’. The concept refers to the structures which function substantially as providing information rather than habitation (Ranaulo, 2001).

3.3.2 Mediatecture

Style of each era strongly affects architecture and space. The contemporary era has created fuzziness in the borders between virtual and physical spaces due to widespread use of internet and advancements in electronics. Christoph Kronhagel who is a technology and media facade expert, proposes ‘Meditechture’ term which is a blend of ‘media’ and architecture. Mediatecture presents ideas and concepts which are the aim of media architects and artists (Kronhagel, 2010).

The conceptual structure is kept open and flexible on purpose in order to obtain a synergetic architecture and electronic media implementation by means of a process of discourse or a type of interpolation. Mediatecture is not an invention of the 90s; rather it is founded upon various historic attempts and ideas. In the 1960s, there were some attempts to use media and electronic technology to address senses of visitors and accordingly to enhance spatial environments. Despite the fact that only few of those attempts were implemented, there are still some of those projects like Philips Pavilion by Le Corbusier that are frequently cited today. Visitors are encountered with an audiovisual experience in which colored lights and sound are integrated (Wirths, 2004).

This experience provides the opportunity for the visitors to directly perceive the pliable borderline between real and virtual space's interface and may help them to deal more consciously with the widespread role of electronic media in their social and urban environment (Williams, 1999).

Media facades create a new link among digital space, architecture and urban space. There has never existed a public interface between digital and physical world to such a great extent. This seems to be appealing to individual users of personal computers as well as groups or urban populations who have interaction with a facade or are designers of its content (TscherteU, 2008).

Media facade can be categorized according to different points of views: permanent or temporary elements, character of media facade or media content, prerecorded media or live media on the facade, physical or mechanical tools. However, in this part two types of media facade are selected and briefly described. They are considered from installation point of view: Install elements on the facade – BIX Installation and GreenPix Zero Energy Wallor, the second type is projecting on the facade Digital Water Pavilion. These projects are chosen because they are considered innovative as regards technology, and are able to convey different messages and are designed for significant events throughout the world.

3.3.2.1 Installation Elements on the Facade

BIX Installation in Austria is an example to install elements on the skin which was constructed in 2003. It is light with a low resolution and media facade for the Kunsthaus Art Gallery. This is one of the recent examples of communicative display in which images and graphics of the installation represent what is exhibited in the museum currently. One of the distinguished features of the building is the blue facade which is made of plastic opaque tiles. 930 ring-like fluorescent lamps which are computerized are installed behind the skin. Though rings of light have been used before, the idea of creating a digital exhibition with usual fluorescent lamps is considered as innovative. Each lamp functions individually as an independent pixel and creates graphics with a low resolution (Čikić-Tovarović, 2011). Although those large pixels create low resolution graphics, they provide reading and registering images from far distances (Figure 26).

Figure 26: BIX building, day and night, (Abo-Moussallam, 2011)

GreenPix or Zero Energy Media Wall in china which was implemented in 2008 is an example of sustainable digital media technology applied on a glass wall in an entertainment complex named Xicui. The building is considered as an organic self-sufficient system which possesses the largest color LED in the world. It also has the first photovoltaic system and has the ability to supply its own required energy for light production. Photovoltaic cells receive and absorb solar energy and consume it for screen illumination and display of light overnight. This facade is able to display playback videos, and live performances and contents. It also has the capability to show user-generated contents which are mainly designed by artists. The opaque commercial building which looks like a box has a communicative perspective due to its technological intelligent second skin. GreenPix as the "information face" of the structure transmits the message of the City, that is, sustainable technology (Abo-Moussallam, 2011) (Figure 27).

Figure 27: Greenpix – day and night, (Abo-Moussallam, 2011)

3.3.2.2 3D Projection Mapping

As an example, Bombay Sapphire in London, the iconic gin, provided members of the public with an opportunity to experience a highly exceptional evening filled up with imagination upon the River Thames on 8th of June 2011. From its very beginnings, Bombay Sapphire has ended the conventions of gin by means of imagination power– from offering innovative recipe and unique processes of distillation to its statement blue bottle and creation of new cocktails. After the re-imagination of gin, Bombay Sapphire set out to inspire evenings out infused with imagination –fostering a break with what is considered as the norm and a drive to explore evening experiences which are unexpected and imaginative via a series of forthcoming events in 2011(Figure 28). It is the follow up of a previous 3D projection campaign that displayed sea creatures in a blue ocean which were projected onto Queen's House in Greenwich in September 2009. Following the first projection, fans on Facebook proposed ideas for the projection of Battlesea Power Station and the winning idea was a giant Rubik's cube that was selected as the theme for the Re-powered campaign. This projection is an instance of using an iconic landmark building in 3D projection events (Binay, 2012).


Figure 28: Bombay Sapphire - projections mapping, (Binay, 2012)

The other example of projecting display is Digital Water Pavilion in Spain which was designed inspired by the Expo's primary theme: "Water and Sustainability". Therefore, the content of the show is designed within the same building context. Texts and patterns reflected on water curtain are representative of the building's function as a center for disseminating information. Besides, the water curtain is able to display light with lighting sources of LED. In addition, there is a dynamic roof that is moved and controlled by utilizing hydraulic pistons and a system for activation. Another significant feature of the pavilion is its fluidity where digital technology uses the dynamism of water. Water walls produce visible as well as invisible components of facade such as windows and doors that generate a ‘dematerialization of architecture’. An integrated sensor technology is used on the pipes which creates dynamic patterns on the surface of water. Hence, the visitors are able to interact easily with the building (Čikić-Tovarović, 2011) (Figure 29).

Figure 29: Water imagining system, (Čikić-Tovarović, 2011)

a. Advertising Exhibition

The base of digital technologies is developed by advances in interfaces and instruments such as scales, calculators, scanners, processors, printers, photography, computers, internet, etc. Moreover, the development of software for the purposes of processing photographs, drawing digitally, generating images by computer, and producing animations has largely contributed to generation of digital artwork (Saglamtimur, 2010). Then, the created work of art will be projected on a certain surface by a projector. In the digital era, projection is considered as an important means of the presentation of the product and communicating with the audience (Udart, 2010).

New media has become a new meeting place and a social platform for people. As more brands choose to employ relationship marketing strategies that emphasize consumer’s experience with the brand, it is inevitable that they explore opportunities to connect with their target audiences in this new meeting place.

Viral advertising depends heavily on provocative content to “motivate unpaid peer-to-peer communication of persuasive messages from identified sponsors” more than traditional advertising. Although emotional content has been the key influencer in captivating traditional advertising audiences, with viral advertising, raw content tends to be a more important element for actual dissemination. Viral advertising works better when the content is surprising, unique, challenging or inspiring (Binay, 2012). One of the most impressive 3D projection mapping campaigns in 2011 was the Adidas France’s “Adidas is all in” campaign event on March 23 2011 at the Palais du Pharo in Merseille, France (Figure 30). It is important that the brand identity, story and associations are in complete unison with the tone of the narrative of the projection (Wells, 2006).

Figure 30: 3D mapping projection on the Palais Du Pharo, (Wells, 2006)

b. Artistic and Entertainment Exhibition

These days, the utility of 3D Video Projection display has improved. It contains 3D images or 3D videos, virtual and real 3D objects. In some recent 3D projection mapping works, an artistic approach is clearly observed. That is to say that mainly images or videos are orbiting around aesthetic aspects and the goal of exhibition is usually contributing to the improvements of the entertainment and artistry of the contents. In artistic exhibitions, architecture is a subject with complex meanings. Sometimes, it is evaluated as public art beyond human convenience (Yun, 2013). Theater, concerts, and public shows in the context are some examples of such an artistic approach.

In 2011, the German Projection Mapping expert group, Mr. Beam introduced a 360 degrees, three-dimensional Projection Mapping technology. This test video "living room" is directed as the furniture and the carpet placed in the room changed as time goes by (Figure 32). The living room is different from Projection Mapping methods of projecting images on the surface of buildings that they used to project onto. In the present model, it focuses on small objects such as furniture. Projection Mapping is used as a space direction of projecting the images onto an area and an entire passage. Viewers can experience the images as a space; it makes them feel as if the virtual and real were fused (Newslite, 2011). Figure 31 presents a white room which is designed to be applied as the base for projecting image onto.

Figure 31: A plain white room to set up projectors, (Newslite, 2011)

Figure 32: Decorated by the light of projectors, (Newslite, 2011)

In 2011, during Rotterdamse Museumnacht event, Sober Industries and Studio Rewind developed two wooden animals (Figure 33) through the use of video projection mapping light. Called 'Welcome to the Future', (Figure 34) these two owls and rhinoceros sculptures possess the surface futuristic patterns and shaped by light-projected (Boyé, 2013). These digital creatures are two wild animals which lived in the forest like the Tron movie. Cube shaped sculptures light up at night with amazing color illuminating surfaces. Flashes of bold color flickered across their faceted shapes, sharply outlining their edges or quickly breaking into flowing organic forms like leaves in the forest.

Figure 33: Welcome to the future sculpture, (Boyé, 2013)

Figure 34: Wooden sculpture, (Boyé, 2013)

Projection mapping is used on a stage-like live performance and fashion show. It creates major changes in the stage and the atmosphere through the use of one motion image. Moreover, it saves the time spent in the installation of the screens and projectors. In recent years, sensor-based device technologies such as Microsoft Kinect, and media art such as open frameworks and processing, have paved the ways for source programming environments for interactive contents, and game engines such as Unity. It is worth noting that many of these techniques have been also applied in some Projection Mapping exhibitions. For example, in a sound festival in Mexico (2013), the executors made a full stage video mapping for representing the global culture (Piloyolip, 2013) on different surfaces such as buildings, canvas and boxes. The result was unique and minimal, but always in interaction with the music. Figures 35 and 36 display two pictures taken from the exhibition. The night performance was full of colors and light with special forms with high quality performance. This artistic exhibition looks like a screen full of colors on canvas which has motion and music as well.

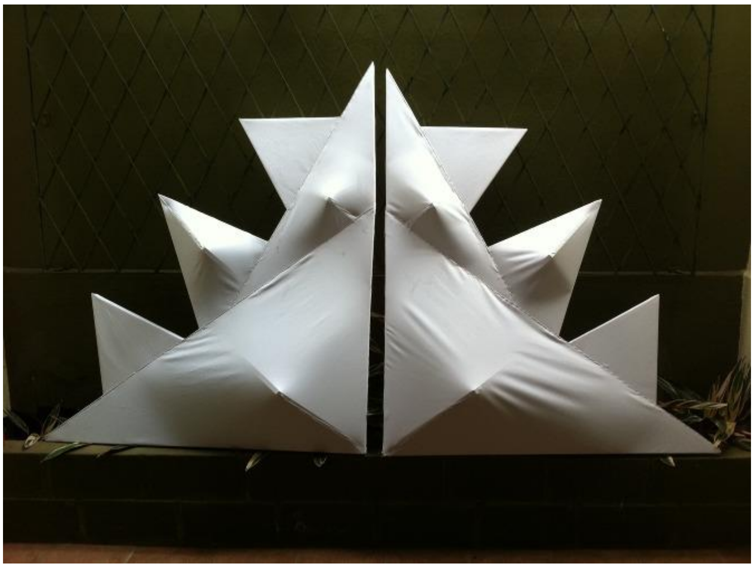

Figure 35: White canvas for stage design, (Piloyolip, 2013)

Figure 36: Stage design in Mexico, (Piloyolip, 2013)

3.4 Evaluation of 3D Projection Mapping's Capability in the Artistic Exhibition; Siena

In this section, in order to investigate the exhibition capabilities of 3D video projection mapping on historical facades in artistic exhibitions, the researcher analyzed the gathered data from an observation of an specific case of using 3D projection mapping technology in Siena, Italy, as well as an analytical discussions on the result of a questionnaire which was distributed among a group of local people in Siena. To achieve a deep understanding of the capability of the 3D projection mapping, direct observation method was used and the researcher was present in the historical context as a participant. In addition, the questionnaire which was used in the present study consisted of multiple-choice questions compiled on the basis of the literature reviews. It is worth mentioning that the questionnaire has been prepared in both English and Italian.

3.4.1 Observation: Location and Description of the Case

Architecturally speaking, the city of Sienna at the heart of Italy is valuable for its well-preserved medieval buildings. And, the Piazza Del Campo, which nowadays is known as the city's central market place is among the most famous examples of such buildings. The outstanding spoke-like paving pattern which reminds the u-shape of the theaters in ancient Greek turns it to an ideal place for different exhibitions (Figure 37).

Figure 37: The aerial photo from Piazza Del Campo, (Wikipedia, 2013)

In fact, the observation method used in the present study was devised for recording basics about the features of the location and activity of the groups, which are attending in this area. It’s surrounded by a number of historical buildings which nowadays are used as shops, café and restaurants in the ground floor. In one corner, there is a tower with 300 steps. In a common view, buildings that were located around Piazza Del Campo have similar forms, character and sky edges. This square is selected for the use of video projection mapping for the New Year ceremony due to the integrated facades which let project 360 degree at the same time. A white, marble rectangular-shaped fountain is located at the center of the square.

In general, night lighting views of this square takes place in two forms of conventional external lighting and monochromic lighting, both of which keep the architectural qualities and features of the buildings at night similar to what is seen in the daylight (Figures 38 and 39). At nights, the use of artificial light on the facade of historical buildings around the square turns it to a meeting place for visitors and local people who gather for entertainment and commercial activities. The atmosphere of the square by using yellow lighting on the facades and combination with red color of the building’s brick is warm to public activities.

Figure 38: Day view of Piazza Del Campo, (Nella, 2012)


Figure 39: Night view of Piazza Del Campo, (Nella, 2012)

The great importance point in the present study is that since December 2010 for New Year’s ceremony, a show of historical motion pictures is held on the facade in plaza Del campo through the application of video projection. The new tool provides the privilege of repeating this fantastic exhibition several times, for various reasons and occasions. The exhibition takes about 15 minutes and many people from all over the world attend this entertaining show every year.

3.4.1.1 Concept of Exibition

The general view of this cultural project is artistic and entertaining while visitors enjoy the great popular music of the 1800s with the 'Great Ball of Italy'. The exhibition narrates the historical events related to the unification of Italy as well as some amusing scenes explaining various historical, religious, and cultural aspects of the city of Siena through the application of innovative projecting software for the visitors (Figure 40).

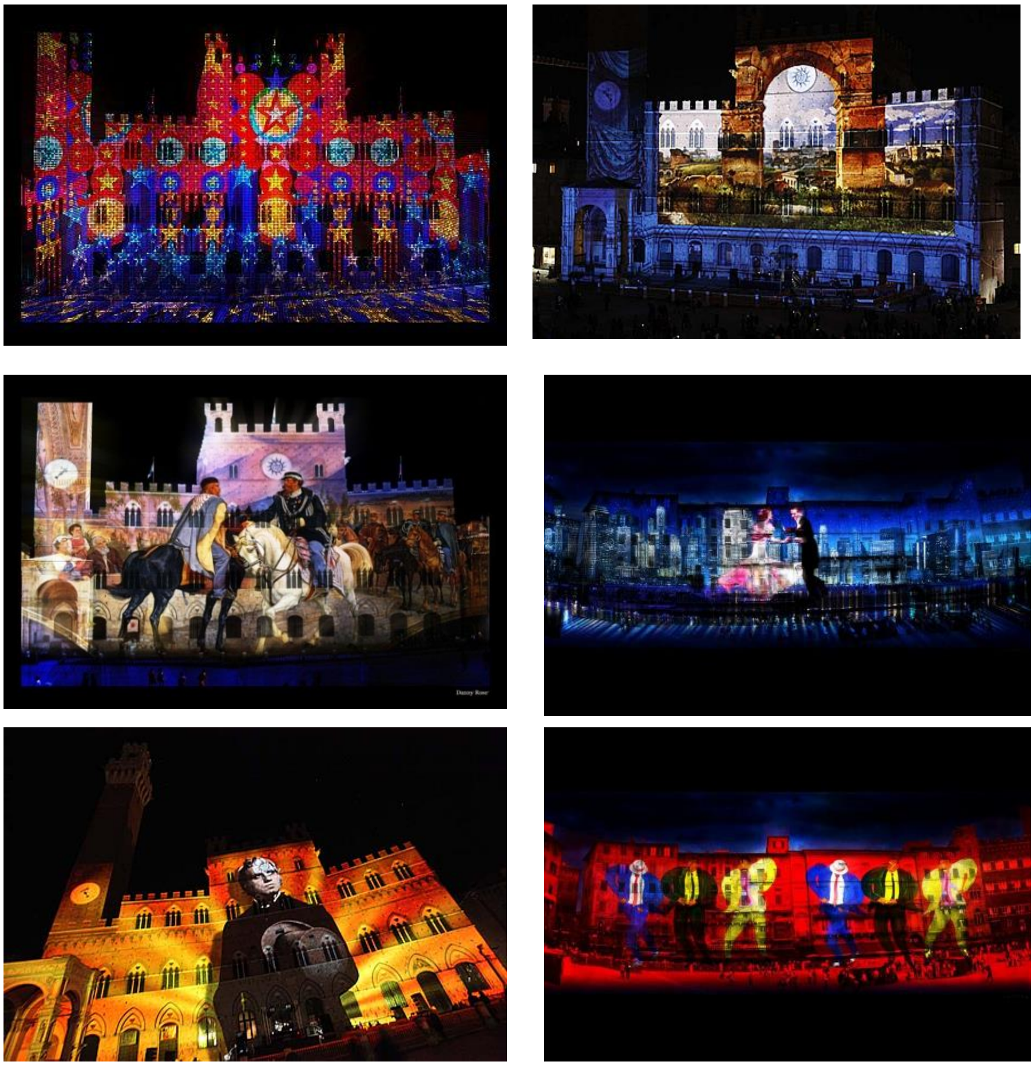

Figure 40: New Year’s ceremony, video projection mapping show

3.4.1.2 Components of Exhibition

Another fundamental issue which is of great importance in this discussion is the cooperation of a group of artists from various artistic fields in the Piazza Del Campo exhibition or what is called “Da Viva Verdi al night clubbing Opera lumiere e dj set”. For the first time, the exhibition was performed by Danny Rose in 2011. The artistic group is composed of a writer, director, animation specialists, sound effect technicians, musicians, and technical directors. While video projection exhibition can be seen as the background of the ceremony, music and animation effects enrich the quality of the performance to make it a unique artistic masterpiece.

3.4.2 Questionnaire

The questionnaire which was used in the present study was prepared according to the capabilities of 3D projection mapping with the aim of estimating the quality of projecting on the facade through the application of such technique. The questionnaire consists of six questions, five of which were in multiple choice formats. In addition, the researcher used an open-ended item to give the opportunity to the participants to express their personal views regarding the event.

It must be noted that the researcher avoided to distribute the questionnaire among the visitors, instead preferred the local ones due to the fact that the visitors are not familiar with the original views of the buildings. People who fill the questionnaire are among those who work in shops around the square and were selected randomly by the researcher. Table 1 illustrates the characters of 3D projection mapping briefly according to literature reviews. The influential factors are displayed in the table below (Table 1).

Table 1: Key factors of evaluation

<table>
<tr><th>Capabilities of 3D projection mapping on the facades</th><th>Reference</th><th>Key Factors in evaluate this study</th></tr>
<tr><td>1- Create dynamic images</td><td>(Ekim, 2011)</td><td>-</td></tr>
<tr><td>2- Sound effects (narrative, music)</td><td>(Ekim, 2011)</td><td>-</td></tr>
<tr><td colspan="3">3- Light</td></tr>
<tr><td rowspan="5">• Detail Lighting
• Conventional
• External Lighting
• Dynamic Lighting
• Communicative Lighting
• Monochromic Lighting</td><td>(Zumtobel, 2010)</td><td>✓</td></tr>
<tr><td>(Heritage, 2007)</td><td>-</td></tr>
<tr><td>(Cie, 2007)</td><td>-</td></tr>
<tr><td>(TscherteU, 2008)</td><td>-</td></tr>
<tr><td>(Djokic, 2012)</td><td>-</td></tr>
<tr><td>4- Adaptability and Flexibility with buildings</td><td>(Sahin, 2013)</td><td>✓</td></tr>
<tr><td>5- Perception of an object from a distance</td><td>(Sahin, 2013)</td><td>✓</td></tr>
<tr><td>6- Link historical contexts and buildings</td><td>(Sahin, 2013)</td><td>-</td></tr>
</table>

In fact, the researcher asked various questions from the participants while gathering the information to understand their perception and feelings (Appendix). However, only six of these questions were worth evaluating and discussing in the analysis.

Accordingly, the questionnaire consists of four parts: the quality of lighting in this exhibition, the quality of projecting realistic images, the quality of adaptability and flexibility of exhibition with buildings, and clarity of the objects from distance in the exhibition.

- **Quality of lighting**

In this section, the researcher evaluated the quality of lighting on the historical facades by 3D projection mapping through. The first question aims at comparing the lighting which is usually used at ordinary nights in the site with the lighting used in 3D projection mapping technology in the exhibition. This question specifically evaluates the capabilities of "realistic" lighting which is considered as one of the most influential factors for detailed-specific exhibitions. 75 percent of audience had selected 3D projection tools for realistic lighting, while 25 percent had selected other tools. This answer displays that 3D projection mapping has the capability of creating appropriate and realistic lighting for the exhibitions like the one we discussed in the previous section, which usually allocate to the facades of historical buildings.

The second question explores the capability of "detailed" lighting provided by 3D projection mapping tool. 90 percent of the participants assert that the use of some detailed images of Del Campo square's buildings in the exhibition, attract their attention to some of their detailed aspects. For example, through the 3D projection mapping technique, the image of the famous clock of the city was enlarged and focused in the exhibition as a symbolic presentation.

- **Quality of displaying realistic images**

The third and four questions of the questionnaire are about the quality of projecting realistic images on the historical buildings. Third question addresses the visual aspect of the projecting with the purpose of questioning the relationship between a historical facade and the projection tools to create a realistic image. According to the responses, 83% satisfaction shown in the results is a confirmation of the effectiveness of 3D projection mapping technique in creating a realistic image on the historical facades.

The fourth question is allocated to the clarity, softness of the edges, and the color of the images. The answers given to the open-ended questions in this section revealed that the clarity of the images was close to the technology used in 3D movies. 25 people express their satisfaction of the quality of the images and some say the exhibition was so memorable. Considering the clarity of the edges of the images used in the exhibition, 12 participants mention the high quality of the images and that the edges of the images were not flow, however, others had not paid attention to such detailed qualities in the exhibition. Yet, the quality of colors in the exhibition was significantly more interesting than the clarity of the edges of the images and approximately all the participants were amazed by the high contrast, clarity, and richness, and vividness of the colors used in the performance.

- **Quality of masking images on the facade**

The fifth question of the questionnaire has approximately the same concept as previous question with the difference that in this question adaptability and flexibility of images with buildings of the place is evaluated. The result of this question is also positive and confirms the effectiveness of the use of 3D projection mapping on the display of the facade of historical buildings. Such a technology has the capability of masking various images on the facades which can be used for different purposes.

- **Quality of display from different distance**

The forth question investigates the quality of presentation of images from distance. In this question, each person answered according to his or her distance from the facade during the exhibition (between about 2 meters and about 30 meters distance between the audience and facade). The answer of audiences near the building is the same as those who were far away from the building. It means that the quality of presentation in different distances is the same; moreover, it can be concluded that the distance is not an essential factor in the evaluation of the quality of the images.

The results of the questionnaire and observation signify the capabilities of 3D projection mapping technique in exhibitions on building facades. In the next section, the researcher uses such capabilities as high quality of lighting, presenting realistic images, masking capabilities, as well as high clarity of the images from the distance for suggesting an innovative method for reconstructive purposes.

3.5 New perspective in the application of 3D projection mapping; Virtual Reconstruction Exhibition (Visual Facadism)

The concern for the preservation of cultural and architectural heritage of a society has been a discussion among architects, historians, state leaders, and; later, local neighborhood organizations, municipal officials, preservationists, and planners. The critical point of these concerns is how to maintain the cultural architectural legacy of a place along with accommodating and modernizing its development and growth (Bräuer, 2008).

To better understanding of the present study, the reconstruction of the facade of historical buildings categorized. One is the **physical reconstruction** which has been practiced in different countries; according to their rules to reconstructing historical buildings with various techniques and the other is **visual reconstruction** which involves the projection of light and image on the facades. According to the main goal of the research, **physical reconstruction** isn't in the area of the research and one of these approaches of reconstruction will be discussed briefly in this section. Most often, a building is either preserved or demolished. Investors who seek to create a balance among these conflicting imperatives, make compromises and decisions the result of which can be seen in the built environment in any city (Timchenko, 2000). Sometimes this act of balancing leads into preservation of a building or a neighborhood; however, in some other cases, it ends up in demolition. In some cases, an attempt is made for satisfying the demands and desires of all investors. On of this action is manifested physically in the term 'facadism' as referred to by preservationists. Facadism implies an attempt through which the facade of a building is preserved while its other parts are demolished to be replaced by new ones.

Facadism is definitely a compromise made between preservationists who are willing to preserve a building for next generations and developers who seek to increase the rate of return of their investment by maximizing the space to be rented and providing modern amenities to enhance asking rents. However, it should be noted that, even developers are sometimes interested in preserving some historical elements of a resource to generate an attractive, more marketable, and unique project (Schumacher, 2010).

In many cases, it is more economical to demolish the interior sections and integrate the historical facade into the new construction than it is to maintain an entire building. Therefore, the discussion becomes one of significance versus economics. When these discussions end in facadism, the integrity and context of a historical building will be lost. This is not preservation as outlined in international charters on conservation, federal preservation standards, nor within local ordinances. Instead it can be interpreted as an empty gesture towards preserving the history of a building, street, or neighborhood, while removing the structure and interior of a historical building reversibly and banishing it as a street decoration (Korumaz, 2012).

Apart from the traditional methods in preservation and presentation of architectural structures, facadism is one of the ways which specifically serves the purpose of preserving the facade of historical buildings (Wiedemann, 2000).

Digital recording of monuments, buildings, sites, and cities along with displaying the recorded images will help to the preservation, presentation, and dissemination of architectural heritage. The foundation of international organizations that define strict specifications for the historical building's proper documentation proves the necessity of recording and documenting historical buildings.

According to ICOMOS (The International Council on Monuments and Site) every national and international organization that is in charge of monuments made by humans and historical buildings has also the responsibility to document them exploiting suitable methods such as written analysis and description, photogrammetry, rectified photography, photographs (either terrestrial or aerial), maps, geophysical research, measured plans, replicas, drawings, sketches or other modern or traditional technologies (ICOMOS, 2013). Historical buildings are a component of both local and global cultural heritage; therefore, digitizing them in the form of 3D is a unique advantage which can save them in the era of digitization (Schumacher, 2010). Visual preservation of the historical value of buildings by employing new technologies, and using it to create a space which is harmonious and compatible with the modern life of the human beings can be helpful from cultural and educational perspectives. It also contributes to the creation of a relation with the background history of historical spaces (Bräuer, 2008). The present study proposes use of video projection mapping in visual reconstruction of historical buildings. Video projection mapping is able to function as a lighting tool for the facade of buildings through projecting the reconstructed image of the historical buildings on them. Since the main function of this approach in this study is **visual reconstruction of historical facade** and the main goal of reconstruction of historical facade is preserve facade, it can be referred to as '**visual facadism**'.

The summary of the present chapter is presented in Figure 41.

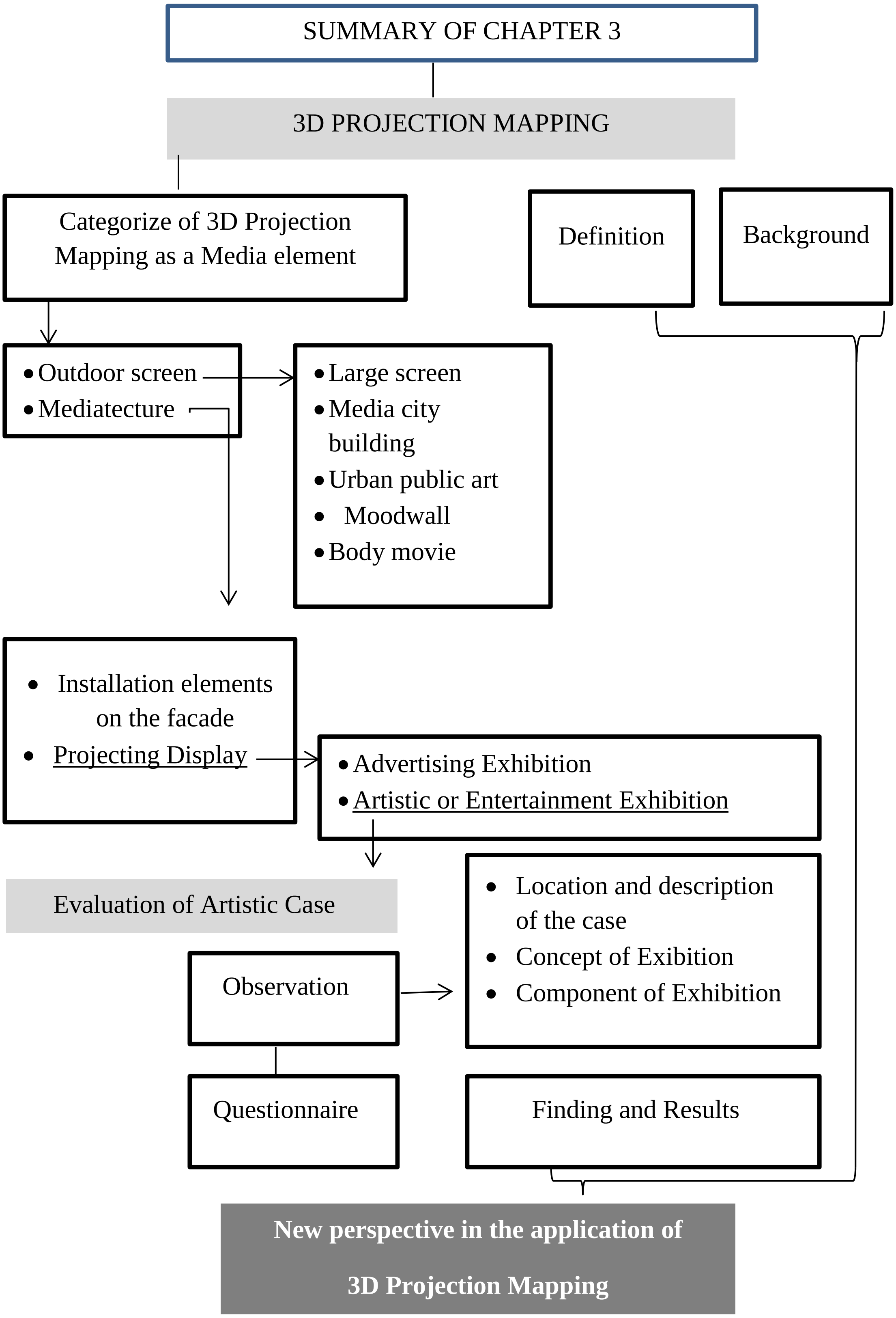

Figure 41: General view 3D projection mapping as a media

Chapter 4

GUIDELINE FOR 3D PROJECTION MAPPING

According to the presented introduction and definition for video projection mapping and the mentioned objectives of the present study, it can be suggested that applying this system on a building involves different steps which will be elaborated in this chapter. To have an overall view of the procedures, it could be noted that to initiate this process for use of the system in different reasons, some steps isn't useable and it can omit from the process. For instance, in artistic or entertainment works and advertisement work a conceptual framework needs to be created, while for reconstruction works it doesn't need. The next step, Location Study, involves acquiring comprehensive and accurate information about the shape, size and orientation of buildings in a certain site, which helps designers to approach their ideas and predict the plausibility and applicability of their design. In some projects a design is projected onto the building without making precise measurements depending on the decision of the designers. However, regarding the topic of the present study , measurements are of a great significance, which lead to accuracy in implementing the project and projecting the image on a certain historical building.

The third step and the last step which are beneficial in all works involve creating a particular image using computer software based on the collected information. The image should be suitable for the selected building and is supposed to have minimal error. In the next step, designers model the building manually and try projection of images on a real object model of building; meanwhile, they estimate the distance and place the projectors need to be installed, the right number of projectors, and the correct angles. The final step which is the lastpart of the application is projecting the real image on the building in the form of 2D or 3D. This part can be considered as the ultimate result of the previous steps.

4.1 Gathering Idea and Sketching

Collecting ideas and information is a critical step in the development of a solution to the problem. Therefore, the structure of the problem should be observed and fully understood, and fundamental keywords need to be gathered for the sake of analysis. Scenarios are used effectively in conceptual design to explore the ideas for the artwork. It is a construct of a sequence of the story, theme that delivers the message to viewers and builds an emotional connection between the artwork and viewers (Ekim, 2011). Sketching is a main phase in application process. It helps to improvise visually and express a preliminary image of the intended final artwork. The important issue for an effective performance is to choose the right technique to apply on artwork. In that, the artwork interacts with the audience. This interaction is provided by technique and its components to get feedbacks from the audience (Jonson, 2002). Figure 42 is a summary of this step.

CRITICAL STEPS	
Step 1	Collecting ideas and information
Step 2	Observe and fully understand the structure of the problem
Step 3	Analysis of the problem by fundamental keywords
MAIN STEP	
Step 4	Improvise visually and express a preliminary image of the intended final artwork

Figure 42: Gathering idea and sketching steps

4.2 Location Study

To document any historical building as a cultural heritage, information needs to be collected and further communicated through the use of modern technologies (Ippoliti, 2012). Therefore, a large variety of techniques and technologies can be deployed. Some are laser scanning-based, some other are based on surveying-photogrammetric techniques, some employ empirical methodologies and others are established upon imaging techniques. Since the digitalization needs which rise from a particular monument are complex, identifying a certain methodology that can be applied in all cases is almost impossible (Sormann, 2010).

In digital recording five major processes are identified. The processes are illustrated graphically in Figure 43 it should be noted that each process needs the implementation of a more complex software and usage of a new hardware. 3D digitalization is regarded as the first step of a sophisticated process that results in the complete recording of a historical building. After digitization, other process consist of **Processing and storage of 3D data** which is a process of save data from collected information, **Archiving and management of 3D data** is a process to organizing data and filing data in memory of computer, **Visualization and dissemination of 3D data** means spread data by software, **Replication and reproduction of 3D data** which is the last step of the location study is coping and reproduction of an image from data.

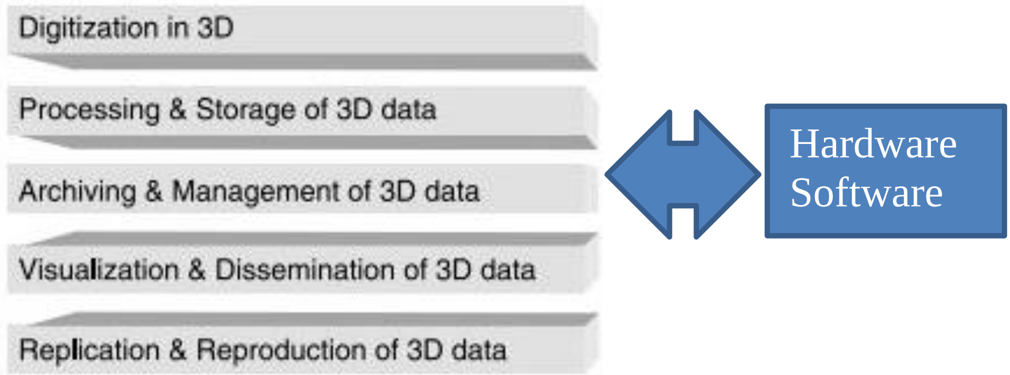

Figure 43: Complete recording of cultural heritage, (Sormann, 2010)

In this study, **Digitization of historical building** explains firstly then other fourth process will be applying by computer software after it to complete Location study to recording of historical buildings.

4.2.1 Digitization of Historical Building

This process includes multiple leads to the complete recording of a historical building. This process consists of multiple steps and involves variations depending on the requirements of a particular application. 3D digitization of a historical building or a cultural content is implemented based on the size of the objects on which digitalization is applied. Depending on the requirements of the application and technical restrictions, digitalization of the historical buildings is distinguished from the digitalization of the objects. Digitalization of historical buildings is mainly based on traditional techniques of survey in most cases (Pavlidis, 2006). These methods are reviewed briefly below.

4.2.1.1 Empirical Technique

In order to record historical buildings through employing empirical techniques, distances between critical characteristic points of the surface are measured manually (Figure 44). A coordinate system which is arbitrary is devised and the coordinates are defined accordingly on a plain surface of the historical building. This method can be applied successfully when the complexity of the facade of the building is low or recording a sectional plan or different exterior is required (Pavlidis, 2006).

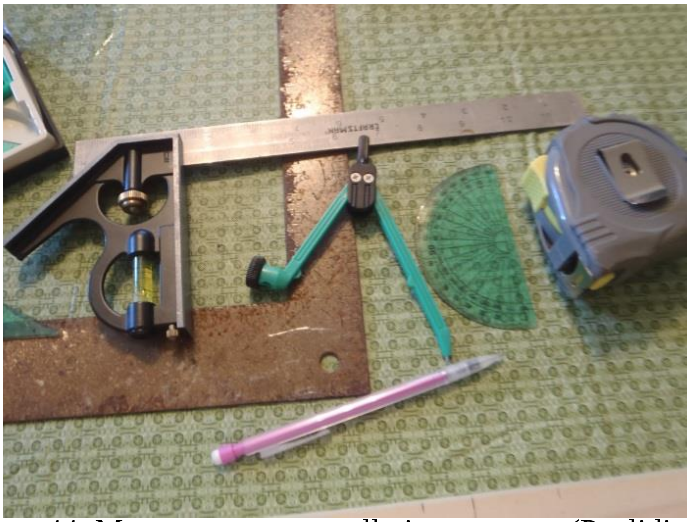

Figure 44: Measurement manually instruments, (Pavlidis, 2006)

4.2.1.2 Surveying Technique

Through the use of complicated and accurate devices for measurement, surveying techniques implement coordinate systems which are 3D orthogonal (Figure 45). This method employs a ‘Total Station’ tool which measures angles and distances of characteristic points on particular surfaces of the historical buildings. These measurements are then changed into coordinates which follow the orthogonal coordinate system established initially. This method is considered as highly accurate and objectivity in its measurements. Besides being reliable, the process of data measurement is easy in this method. Although the survey method requires a long time presence on the site, it is the most ideal method for developing models in the scale of 1:50 or smaller ones with a high degree of accuracy (Boehler, 2002).

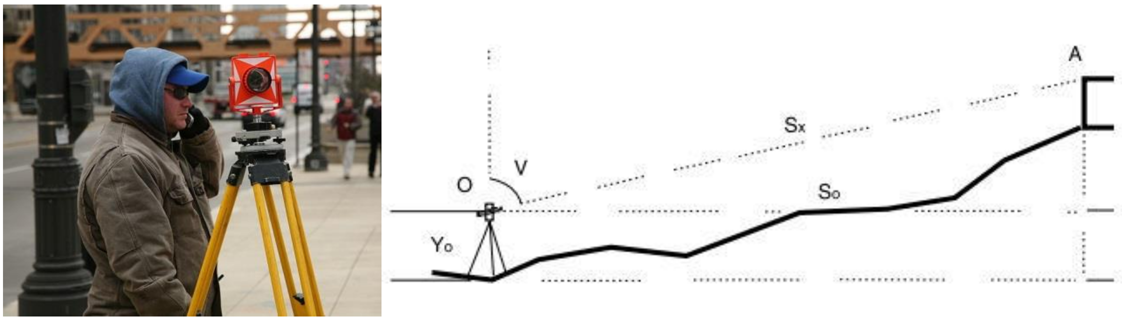

Figure 45: Topographic measuring devices, (Sormann, 2010)

4.2.1.3 Laser Scanning Techniques

Topographic quantities are mainly measured by laser scanners (Figure 46) which are regarded as advanced geodesic stations. These instruments are used for measuring the direction of an optical line which joins the characteristic points of a historical building surface. Laser scanning techniques are highly advantageous because they are accurate and productive, and are able to produce data for measurement in a fraction of time. Reliability and objectivity are two other positive features of these techniques. However, it is worth noting that laser scanning techniques are expensive and although they can be applied on any historical building digitalization project, exposure to very bright light can affect their accuracy (Hank, 2002).

Figure 46: 3D Laser scanner, an advance measuring tool, (Hank, 2002)

4.2.1.4 Photogrammetry

In appropriate conditions, digital photos can be used for measurements which are as accurate as the measurement data collected by the topographic methods. 2D or 3D coordinates can be deduced from a few photos through application of processes of orientation and transformations commonly used in digital photogrammetry (Figure 47). Reliability and objectivity are the main features of this method which can be supported by CAD software. Applying this method is simple and relatively cheap. However, it should be integrated with empirical or topographical methods of measurement. Provided that there is sufficient distance between the historical building and the location of photography, this method can be employed for objects which are complex and surfaces with details. Moreover, in cases that direct access to a historical building is impossible or prohibited; photogrammetry method is useful (Tsioukas, 2003).

Figure 47: 2D or 3D measurements by one or two photos, (Tsioukas, 2003)

Combination of photogrammetry with highly accurate measurements is able to produce precise models for scales of 1:100. According to Balodimos (2003), photogrammetric modeling of historical buildings which are culturally valuable has become more prevalent in recent years. It is considered as an appropriate means of documenting historical buildings, which can restore the fundamental geometric and thematic information with a fast speed and easily. Evaluation of the four techniques is illustrated in Table 2 it should be noted that each process has advantages and disadvantages. Moreover, each method is suitable for a particular facade.

Table 2: Evaluation of creating digital 3D image of historical buildings

Technique	Work Process	Advantages	Disadvantages	Suitable For
Empirical Technique	Measuring manually Recording a sectional plan	Simple productive Portable Low cost	Low accuracy	Low complexity façade
Surveying Technique	Measures angles and distances of characteristic points on particular surfaces of the historical buildings	High accuracy reliable Easy measurement	-	High complex façade ideal method for scale of 1:50 or smaller ones
Laser Scanning Techniques	Measuring the direction of an optical line which joins the characteristic points of a historical building surface	Accurate Productive Fast way	High cost Affected by very bright light	-
Photogrammetry	Digital photos can be used for measurements	Relatively simple Low cost Fast way	For measurements it needs for adequate space	- high surface detail - suitable for models for scales of 1:100

4.3 Creating Digital 3D Image of Historical Buildings

To create a 3D model in a standard approach, tools such as CAD software can be used, which provides the basic elements in the form of 3D shapes. Measurements from maps or drawings and data obtained from surveys are also required. This modeling technique is based on geometry and is costly, time consuming and in some cases impractical. However, the developed models do not realistic and look computer generated. Moreover, delicate details and irregularities of the surfaces cannot be included in the model.

Recent techniques have been developed to increase realism and the level of automation. These techniques like 'image-based modeling', 'image-based rendering', or 'range-based modeling' initiate the process with actual images or use laser scanners for direct digitalization. It should be mentioned that none of the above mentioned techniques can provide all the requirements for being applied to large environments such as a historical space (Werner, 2003). The approach which is suggested in the present study is able to help the design get closer to its objectives and employ all the advantages of the above mentioned approaches to reach the best quality in presenting an image. Therefore, it can be claimed that is an integrated technique which is described below.

4.3.1 Semi-Automatic Image-Based Modeling

This approach is usually utilized for man-made objects like classical architectures. Designs of these structures are often constrained as far as proportion and configuration are concerned. Classical buildings are divided into architectural elements. In order to produce the full structure, these elements are given a hierarchical organization. If components of a classical architecture are defined, reconstructing it is possible though they are partially revealed in an image. For instance, a columnar is composed of the capital, a horizontal element on top, the column, a vertical cylinder which is tapered, and a base on which the column is placed. Every single element can be divided into smaller components. Other elements such as arches, niches, pillars, banisters, pilasters, windows, and doors can be treated likewise. This approach which is based on photogrammetry is neither completely automated nor relies fully on a human operator. In semi-automatic image-based modeling accuracy and details are preserved and sufficient help is provided for the user. In Figure 48 the procedure is summarized and interactive and automatic steps are distinguished (interactive operations are orange, Automatic steps are blue).

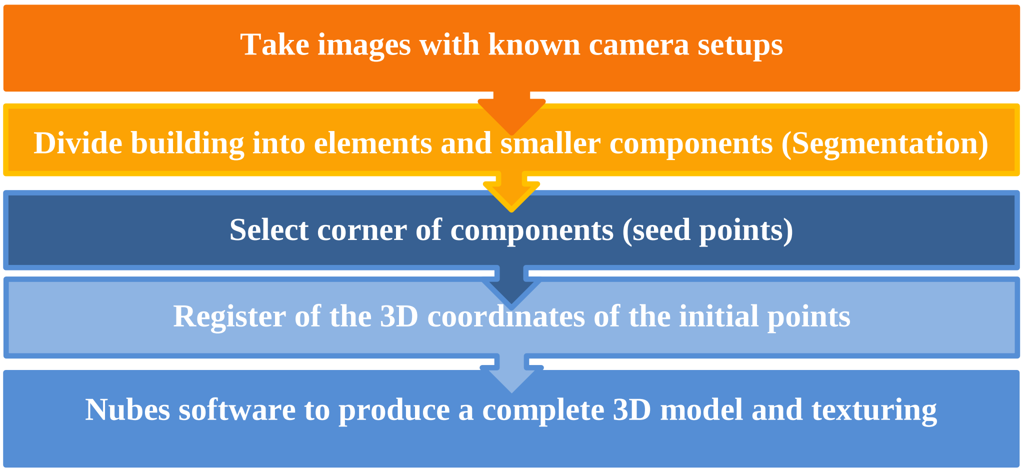

Figure 48: General procedure for image-based modeling

Here, views that are separated widely and seem to be more practical for scenes with large scales are elaborated. The focus is on images with known camera setups. There should be a reasonable distance, or baseline, between the images to guarantee a solid geometric configuration. Normally 12-15 features for each image are extracted. One corner is selected with a unique number label and the system has the ability to recognize and extract it accurately. Registration of the image and computation of 3D coordinate is established on the adjustment of photogrammetric bundle because of being accurate, flexible, and effective (Zhang, 2005).

Registration of the 3D coordinates of the initial points and all the camera orientations and coordinates is facilitated by bundle adjustment in a coordinate system. In the next step of the process the scene is divided to linked segments for defining topology of the surface. Then, more points are added to every segmented region by employing an extractor which automatically extracts corners and matching procedure over the images. Since in some cases one image includes some parts of the scene, an approach for obtaining 3D coordinates from a single image is required. A variety of constraints are determined for the shapes of surfaces such as cylinders or planes and relations of surface like parallelism, symmetry, and perpendicularity. The points which have been measured previously can be used to calculate the equations of certain planes. Depending on being parallel or perpendicular to the planes determined before, the equations of the planes which are remained can be determined. The equations of the main planes of the structure and also those which other elements of the structure are attached to can be calculated easily. From the obtained camera parameters and equations for every single image, 3D coordinates can be determined for each image and there is no need for marking the surface. This technique can be used for quadric or cylinder surfaces and equations can be computed from the points which are already existing (Gonzo, 2002).

As it is illustrated in Figure 49a, after the radius, direction, and position and distance from four seed points is automatically determined, a cylinder is constructed by the system. The ratio between the lower circle and the upper one can be set by the user in advance. In order to produce a tapered column, the default is set to about 0.85.

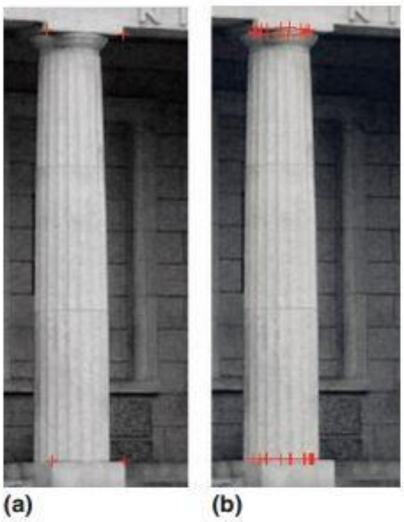

Figure 49: Automatically adds column, (Gonzo, 2002)

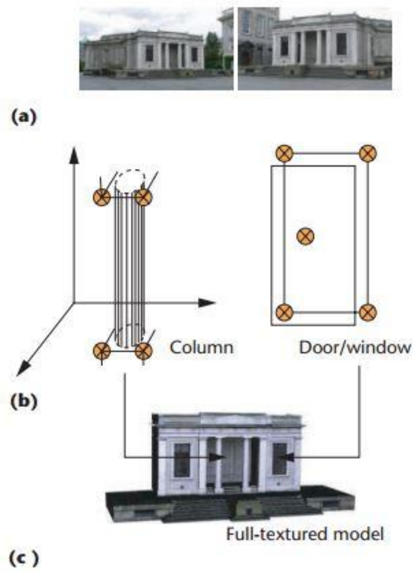

Figure 50: Points of windows and doors, (Gonzo, 2002)

Nubes software is a tool which proposed for specialists in the field of architectural heritage conservation and it is accurate with high speed process. It is able to generate the points on the bottom and top circles of the column in 3D and produce a complete model (see Figure 49b). For doors and windows, three or four corner points and one on the surface are required (see Figure 50). If a plane is fitted to the corner points along with a parallel plane to it at the surface point, the door or window can be reconstructed completely. Figure 51 is a summary of the whole process of Semi-Automatic Image-Based Modeling. Figure 52 illustrates examples of models generated employing this approach (Gonzo, 2002).

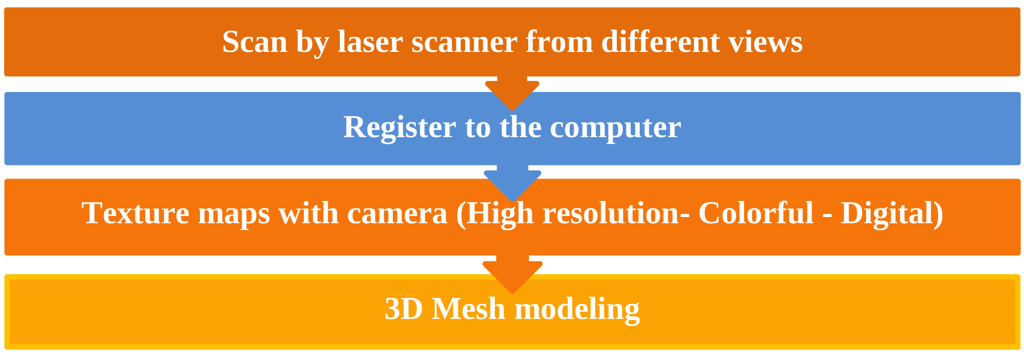

Figure 51: The steps for creating a triangular mesh model from 3D images, (Beraldin, 2002)

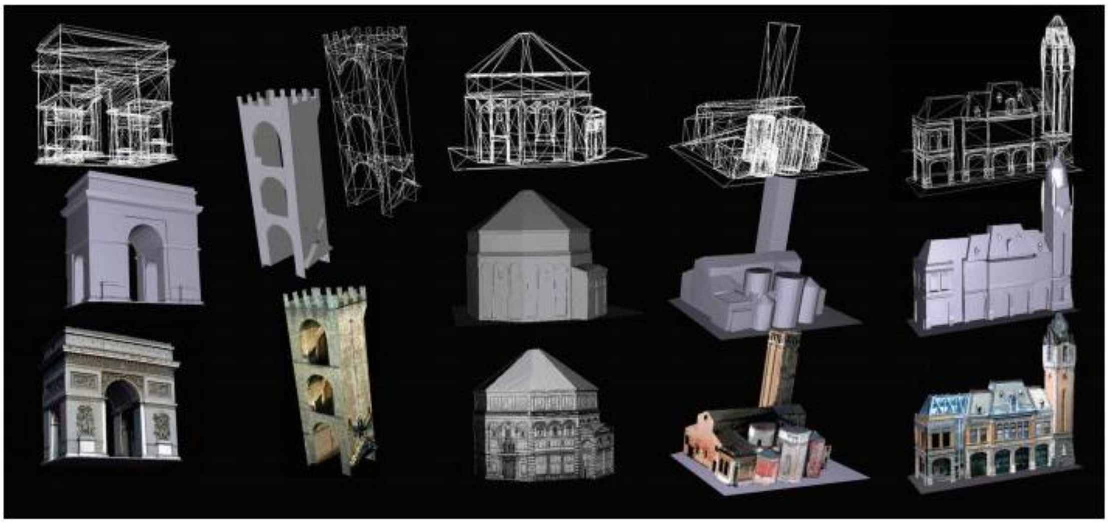

Figure 52: Wire frame, shaded solid, and textured solid, (Gonzo, 2002)

4.3.2 Range-Based Modeling and Texturing

Different steps of producing a mesh model out of 3D images are outlined in Figure 53 As Beraldin (2002) describes, if the 3D data consists of images which are registered, then each image can be triangulated for creating a triangular mesh. However, a great amount of overlap exists between images from different views; therefore, the created mesh might have a lot of redundant faces. Most of the laser scanners can focus on gaining the geometry; so that for each pixel only a single monochrome value of intensity is provided by the laser. In order to acquire a model with a realistic look, texture maps which are produced by color digital cameras with high resolution are required. To register the texture with the geometry, a color camera can be attached to the scanner. However, since the ideal conditions for scanning and the best conditions for image taking might not exist simultaneously, there is a risk of not achieving the desired results (Beraldin, 2002).

4.3.3 Combining Image and Range-Based Modeling

The semi-automatic image based approach is proposed to be used for modeling the whole structure without considering the intricate details and surfaces which are sculpted. Common points existing between the range-based models and images are registered in the same coordinate system. In the next step, points from the range-based model and the related perimeter are sampled automatically and then inserted into the image-base model. To avoid overlapping triangles, the triangulated mesh of the image-based model is adapted on the basis of the new points and a hole to which the rang-based model is added is created (Vassilios, 2005). Table 3 illuminates evaluation of the four techniques briefly; these methods have different benefits in the process of digitization of historical buildings.

Table 3: Evaluation of digitization of historical building

TECHNIQUE	WORK PROCESS	BENEFITS	DISADVANTAGES
3D Model in a Standard Approach (Such as Cad software)	• Obtain data from surveys • Apply to software to create 3D shapes	-	Costly Time consuming Unrealistic
Semi-Automatic Image-Based Modeling	Based on photogrammetry, Process are automate and human operator, reconstruct images with known cameras and software	low cost	Adequacy for medium accuracy
Range-Based Modeling And Texturing	Creating a triangular mesh model by laser scanner, reconstruct images with software	low cost	Risk of not achieving the desired results
Combining Image And Range-Based Modeling	Combining two above process	High accuracy Low cost	-

4.3.4 Landscape Visualization

In cases that it is possible to have images of the entire distant landscape through aerial photography, the scene can be combined with the structures' model. Through this approach the structures can be shown in a natural setting and would look more realistic. Aerial images provide the opportunity to determine the ground points' elevation between the principal structures. The remainder of the scenes and remote objects such as mountains can be represented by spherical or cylindrical panoramas. A few joint 3D points are used between the structures and the ground to record the ground elevation model and landscape panorama with the structures (Vassilios, 2005).

4.4 Architectural Projections

4.4.1 Projection on a Flat Surface

Projecting on a flat surface, like a wall or ceiling is simplest projecting. For a flat surfaces projector is at an arbitrary position, not exactly facing the part of the wall want to project to, the projected image looks distorted. By using Homography, calculates the 2D-homography matrix between two sets of 4 points, can always get a correctly looking projected image on a flat surface independent of the projectors position, orientation to the surface and its lens characteristics.

4.4.2 3D Projection Mapping

Projection mapping is the meticulous alignment of projected images with architectural qualities of buildings, 3 dimensional (3D) objects, or stage sets. High-power projectors are used for projection mapping on buildings. 3D projection mapping is the process of projecting video images on real 3D objects by using video jockeys (VJS) or Video DJ. To perform video projection mapping, applications such as MODUL 8 which are able to mix, compose and project can be used. MODUL8 has been designed for live performers because it is a real time video mixer and composer and is able to project images onto a 3D surface (Cube, 2005). The VJ chooses an inanimate image and projects it in the same direction as the real 3D object. Then, through using the filters menu, the perspective transform is selected by the VJ and the corner of the image is either compressed or stretched. The perspective of the image is changed to the extent that it fits the perspective and dimensions of the surface of the object. This process is referred to as masking. When the inanimate image is fitted to the surface of the 3D object, that is, the 3D object's surface is masked, a video exploiting the same mask parameters is replaced for the inanimate image and can be played on the surface of the 3D object. MUDUL8 has the ability to control more than one projector independently. So within the limitations of the MUDUL8 software, this process can be repeated for the number of surface that the 3D projection mapping has its limitations (Sophrin, 2013). In projecting onto a 3D surface, the position of the projector and oriented towards the surface are important. Note though that there is one point from which the projected image looks perfectly aligned, that is: the position of the projector. To find out the size of screen and a suitable projector, use the Projection Calculator Pro online is easy way (BenQ, 2014).

4.4.3 360° Projection

Within 360 domes generally used a rig of five projectors, with each one playing one segment of a 360 film. These five segments are seamlessly edge-blended together. Source media requires no special configuration to be warped across the two curved planes of 360 projection screens. So it gets a single, consistent, crystal clear image**.**
When even higher degrees of resolution are needed, used up to 15 projectors, meaning 35 million pixels are hitting the screens (Kelly, 2013). Now it is possible to explore virtual environments like the surrounding real world.

4.4.4 Heliodisplay

A holoprojector, also referred to as a Hologram projector, is a tool that has the ability to record, transmit and receive hologram images. Holographic projection is a new trend in technology that will alter the way we observe things in the contemporary era. It will have enormous influences on all fields and aspects of life including education, art, science, business, and healthcare. Before understanding the work process of holographic projector, knowing what a hologram is seems necessary (Elmorshidy, 2010).

Holography is a technique we use for recording patterns of light. These patterns are recreated as a 3D image known as hologram. Technology of 3D holographic projection is inspired by an illusionary approach called Peppers Ghost which was used in Victorian theatres in London for the first time in the 1860s. Pepper's Ghost was used to make figures which looked like ghosts on stage. An actor wearing a ghostly dress would stand in front of an angled glass plate hidden from the view of the audience. The audience could only see the glass not the actor (Elmorshidy, 2010).

Heliodisplay which is essentially air-based uses the air available in the environment (e.g. room or space). The system is generated by IO2 Technology in the year 2001 and deploys a projection unit which is focused onto layers of air and dry atomized particles which are micron-sized in mid-air. The projection results in a two-dimensional display which seems to be floating. The display appears as three dimensional when a 3D content is used. This is because of the cinematic technique used in rear projection and can appear as 3D when a suitable content is used. Since dark parts of the image might not be visible, it might look closer to the reality compared to a projection screen, although it is not considered as volumetric yet. However, when the system is connected to two light systems, dual (back and front) or multiple viewing is possible. An oblique viewing angle of +/- 30 degrees may be necessary for different configurations because of the requirement of rear-projection (Huebschman, 2003).

Through connecting a heliodisplay to a PC by a USB cable, it can function as a free-space touch screen. The PC perceives the heliodisplay as a pointing device like a mouse. Finger, pen, or other objects operating as a cursor control can be used for navigating or interacting with simple contents if supplied software is installed to the system (Popovich, 2001). However, since the year 2010, there is no need to a computer or driver. A processor which is embedded in the interactive version ("i") of the heliodisplay uses the same arrangement of the rear camera in order to control the functions internally for the interactivity of single or multiple touch.

The air-based system is composed of sets of metal plates. The original Heliodisplay could operate for several hours; while new models are able to run continuously. Heliodisplays made in 2008 consume 80 - 120 ml of water per hour, depending on the size of the screen and user settings; despite the fact that the medium of operation is mainly air. Different versions of the heliodisplay predominantly operate with the air around them (e.g. in museum environments) without affecting the space they are placed in. A paper tissue can be put on the exhaust of the apparatus for 24 hours without being affected by moisture in contrast with other mist or fog producing instruments that rely mainly on producing a liquid or vapor and therefore affect the air surrounding them (Klug, 2000).

The Heliodisplay, as a five-inch interactive prototype, was invented by Mr. Dyner in 2001 before the technology of free-space was patented. In the original system an IR laser and a CMOS camera were used to follow the movements of a finger in the air and update the image which is projected to develop the first co-located display with the interface of a mid-air controller. Later, IO2 technology was used to commercialize the original versions and improved in developing the product line over the years (Popovich, 2001).

4.5 Simulation and Modeling

To prove that this kind of product is effectively working, it has been tested on real models and scales. The key technology which can be deployed for the projection simulation on a real model is 3D matching. 3D matching is a means of bringing a virtual three dimensional model in agreement with actual geometry. Due to the agreement of virtuality and reality, many new opportunities can be provided (Frischer, 2008). Even though proof documents such as surveys, 3D scans, or photo plans are available, the best means of verification is conducting a trial in the real area exactly based on the position of the projectors to observe how the projected light frames the building and casts the mask on the surface.

In the conducted experiments, this phase was facilitated by the fact that the facade models which were scaled were constructed based on the surveys themselves. Nonetheless, a precise mapping check-up was required, particularly in the buildings including large overhangs like tympanums, balconies or other sculptural parts that could create shadows on the walls intended to be projected on. The experimentations were carried out in a laboratory using models with scale of 1:50. This allowed simplifying the technological hardware which was required to be used. Therefore, to manage the flow of the video with a resolution 1280x1024 pixel in the format of QuickTime a personal computer was used. Moreover, an inside benQ projector (model MP770 of 3200AnsiLumen), which was connected through a VGA cable and was placed 2.5 m away from the wall where the models were projected on was used (Benedikt, 2008). Figure 53 and Figure 54 show a model of the building in a scale of

1:50. Relevant sections of the building in a digital version were placed at disposal.

Figure 53: Setup model of building, (Benedikt, 2008)

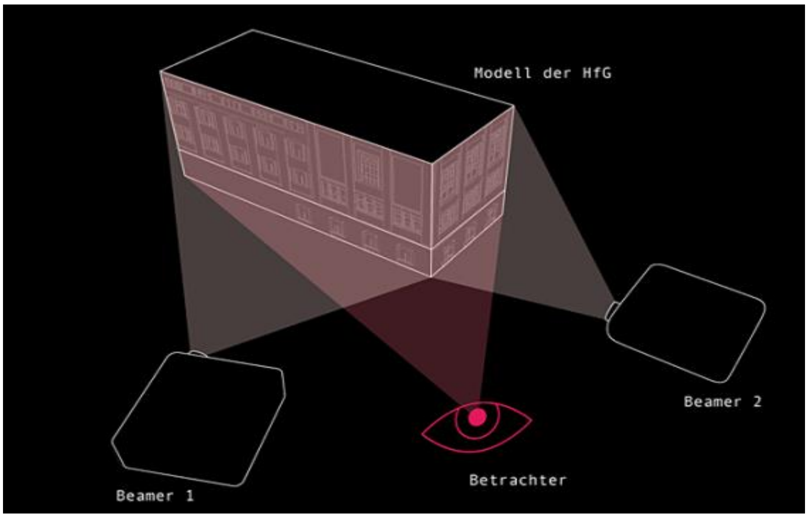

Figure 54: Viewer and 2x projectors, (Benedikt, 2008)

4.6 Performing on Building (Work Results)

Following one of the simplest 3D projection mappings is exemplified which has been viewed by thousands of people on social media. In this part, to understand the process more comprehensively, the Light Wall Project is described.

In ‘Light Wall Project’ a building whose layered facade, ornamental window panes, arch-shape gates, etc. are real three dimensional objects was selected. A moving 3D animated image was projected on it (Figure 55).

Figure 55: Facade of Seoul museum of art, (Yoon, 2010)

The structure of the building is used in depth through the use of actual pillars, gates, windows, and walls as the background. The working process consisted of several steps. Before getting started, the structure of the building was measured and analyzed. In the first step, a preliminary test for three dimensional projection was required to build the miniature model and 2D design. 3D model data of the building were collected as well. After conducting the preliminary test of projection, and when the digital data and the structure of the building were optimized, the design of the two dimensional model was transformed into digital format. In the second step, one server and three client computers were employed. Two approaches were adopted for image distribution from the source. One was the Matrox TripleHead2Go, which is a tool used for expanding graphics for multi-display systems, and the other was using a server client system by means of Ethernet. For serving the purposes of this project, the approach of server system was employed and three projectors were connected to the PCs. The three client PCs were controlled by the operating server (Figure 56). The advantage of the system architecture is its flexibility as regards the total size of the screens by the number of client PCs.

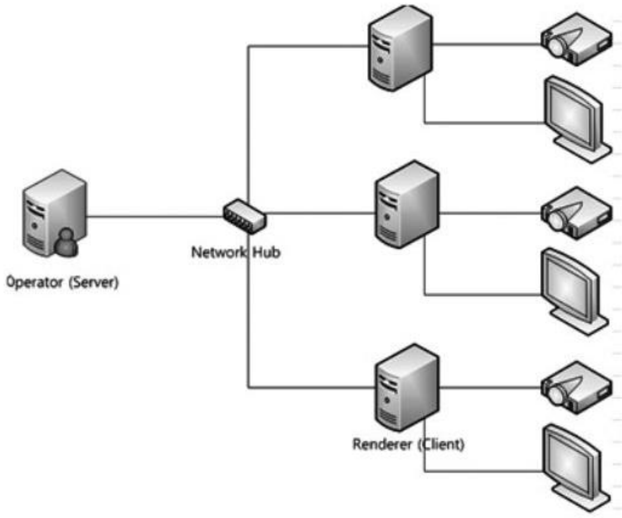

Figure 56: Server system, (Yoon, 2010)

As the third step, operating software was produced based on VVVV. The two dimensional design generated in the second step created images which were unregistered. The technology team developed an original patch for controlling 3D images. The developed patch allows the operator to export, manipulate, and project object files from three dimensional modeling software like 3D MAX or MAYA to VVVV. Adding further functions and effects for the animation is done in the fourth step. Effects, lighting, and shadows are possible to be applied in this step. The final step involves adjusting the building structures with the 3D images to be projected. All the windows were fitted to the image through use of pattern-based control. The projection of the final artwork lasted for 20 minutes. The first part included experiments for the building surface by playing an animation, and the second one was MIOON's artwork Tempo Museum (2009). The performance which was conducted at dusk continued for two months and more than 400,000 viewers watched it (Yoon, 2010) (Figure 57).

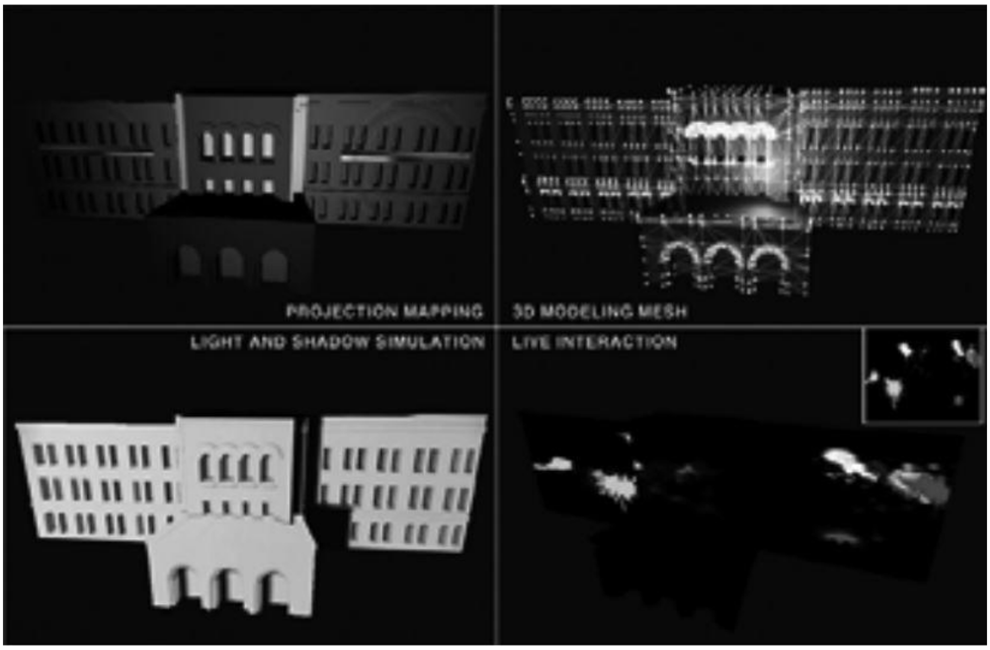

Figure 57: Applying effects, (Yoon, 2010)

4.7 Evaluation of Project

In order to improve and expand the artistic versions of applying 3D projection mapping in historical facades, it is suggested to artists, architects and those in charge of such projects hold questionnaires to evaluate various aspects of the exhibitions. It is through such evaluation processes that these kinds of exhibitions find the opportunity to pave their way in the societies and introduce themselves as useful devices which can be used for various purposes, whether amusement or historical. As a model for evaluating and investigating different aspects of such artistic exhibitions which is expected to be used and improved in other studies, the designed questionnaire, in Chapter 2 can be applied. In addition, to provide a comprehensible image of the whole chapter and the work process of the project, it has provided a chart, illustrated in Figure 58.

Gathering Idea and Sketching

Location Study

Creating Digital 3D Image of Historical Buildings

Architectural Projections

Simulation and modeling

Performing on Building

Evaluation

Figure 58: Summery of Chapter 5, steps of guideline

Chapter 5

CONCLUSION

The main concern of this study is proposed a guideline to virtual reconstruction of historical buildings through deploying the modern technology of 3D projection mapping. To achieve this concern, the first chapter presents an introduction to the subject addressing the background of video projection mapping on historical facade and the main goal of the study, problems and research questions and in particular methodology of the study are statement. The literature reviews are started from the areas which can make a base to the main topic. Historical facade, in general, and lighting historical buildings, in specific, are the issues elaborated on, in the second chapter. Chapter 3 of the present research introduces the background and discusses over the significance of 3D projection mapping as a new trend in the field of architecture, and focuses on the explanation of its' operational procedures. However, since this technology has never been used for the purpose of reconstruction of historical buildings so far, no specific example could be provided for clarification of the issue. Considering such issues, some parts of this chapter is allocated to the artistic and advertising implications of 3D projection mapping is discussed in detail. The final section of chapter 3 focuses on the illustration of a reconstructing project and the related working process of virtual reconstruction in an artistic exhibition in Siena, Italy and the result of observation and questionnaire has been discussed. It is worth noting that the observation and questionnaire compiling process of the present study has been gathered on the basis of various capabilities of 3D projection mapping proposed by different experts in the field. Accordingly, for example, 3D projection mapping can create dynamic images, accompanied by sound effects (Ekim, 2011), or provide lighting on historical buildings (Zumtobel, 2010). It has the capability of providing images which are adaptable on various buildings, and provides high perception of an object from a distance which can link historical contexts and buildings (Sahin, 2013). However, the capabilities which were mainly focused in the present study were as followed: the quality of lighting in this exhibition (Zumtobel, 2010), the quality of projecting realistic images (Ekim, 2011), the quality of adaptability and flexibility of exhibition with buildings, and clarity of the objects from distance in the exhibition (Sahin, 2013). These factors examined to answer this question: “what can be an appropriate guideline in the implication of the 3D projection mapping for reconstruction purposes?” Based on the finding of this study, the exhibition by 3D projection mapping provides high quality of lighting, realistic images and the ability to project flexible images on the building with high resolution even from the distance.

The fourth chapter of the present study introduces a guideline for the implicatio of 3D projection mapping technique in virtual reconstructions. The proposed guideline is useful not only for reconstruction purposes, but also for artistic and intertainment, advertising purposes. As illustrated in the table 4, in order to adapt the proposed stages of the guidelines some minute changes should be made. For instance, when applying 3D projection mapping for artistic, entertainment and advertising purposes, the performer does not need to go through location study because he does not need to have all detailed information about the location for such purposes . As a result, here, first step would be gathering idea and sketching which is followed by digitization of historical building; while in reconstruction purposes, the procedure starts from location study with high accuracy which is followed by the third step of digitization of historical building. In addition, as it is seen in the table, the simulation and modeling step is absent in artistic and entertainment and advertising purposes. Whereas simulating and modeling is one of the main parts of the reconstruction purposes. Therefore, the proposed guideline has the ability to adapt itself with various purposes.

Table 4: Application chart of 3D projection mapping

	Gathering Idea and Sketching	**Location Study**	**Digitization of Historical Building**	**Architectural Projections**	**Simulation and modeling**	**Performing on Building**
Artistic and Entertainment	Step 1		Step 2	Step 3		Step 4
Advertising	Step 1		Step 2	Step 3		Step 4
Reconstruction		Step 1	Step 2	Step 3	Step 4	Step 5

5.1 Implications of the study

Along with advancements in technology, various means of reconstruction of the facade of buildings have been implemented. One of them is the reconstruction of the facade of historical buildings physically which was utilized since many years ago. The simplest definition of this method is the renewal of an old building by new materials to an earlier position. One of these methods is “Facadism” which the facade of a building is preserved while its other parts are demolished to be replaced by new ones (Schumacher, 2010). Researcher with the practice of the idea of respect to the facade of historical building proposed the notion of virtual facadism for the first time. This method is an approach of reconstruction which is applying on the facade of historical buildings and reconstructing them virtually. Through implicating the principles of this method, the reconstructed images from buildings are protected. Throughout the study, the researcher makes an effort to propose the virtual reconstruction of the facade and historical facade by different methods. In fact, the major contribution of the study is to suggest the innovative method of projecting these reconstructed images to the facade of historical buildings through the 3D projection mapping, which is supported by a guideline discussed in chapter 4. Following the principles of the proposed guideline provides the opportunity for the visitors to see the building as reconstructed and meanwhile preserves the aesthetic values of the building.

One of the significant problems of the facade of historical buildings is their lack of sufficient light at night. This problem can be tackled and solved through appropriate lighting which highlights the unique elements of a structure and adds to its attraction. Therefore, as a contribution to the field, the present study introduces the video projection mapping as an efficient lighting tool which integrates different capabilities derived from various types of lightings. Since changing facades of historical buildings is almost impossible, applying modern lightings and using media tools for creating images on the facades without causing any damage is strongly suggested.

Another significant aspects of experiments of 3D projection mapping as a media facade is obtaining a “dynamic” appearance which totally differs from the stone stability of a historical building. Through the application of video projection mapping, historical buildings are changed to large screens which contribute to creating a relation among historical buildings, surrounding environments, and the viewers. To this end, real scenes and objects are needed to be first reconstructed in the form of 3D for applications of cultural heritage. Development in methods of scanning with laser, availability of software for 3D modeling, new techniques of image-based modeling, virtual reality, and computer power have all contributed to these applications.

Finally, many motives and reasons can be mentioned for projecting 3D on the facade of historical facade as a reconstruction technique:

- Documenting objects and historical buildings for the sake of restoration or reconstruction in case of erosion, flood, earthquake, fire, war, etc.
- Creating resources for educational purposes for students and researchers majoring at culture or history;
- Reconstructing historical buildings that are entirely demolished or exist partially;
- Visualizing scenes that cannot be seen from certain viewpoints in reality because of their size or issues of accessibility;
- Interacting with objects without the hazard of damage; and offering virtual museum exhibitions and virtual tourism.

5.2 Future study and Recommendations

In the present study, the researcher introduced the new concept of 'virtual facadism' which is a blend of 'virtual reconstruction' and 'facadism' is proposed. The future implications of such approach are still unclear and the researcher in the field can make use of the opportunities which can be provided by such an approach.

In addition, as it was mentioned earlier, the proposed guideline can be used for various purposes. Research can be done to investigate the effectiveness of the proposed guideline for each of the artistic, advertising, as well as constructing purposes. To this end, the study strongly recommends that architects, artists, and restorers should be provided with opportunities to update themselves as regards the use of modern technologies and tools, and gain knowledge about multi-sciences in order to cultivate creativity in the field of reconstruction of historical buildings.

In addition, the study introduces the new concept of Holographic projection as a tool to serve the purpose of reconstructing historical buildings is introduced for the first time. Holographic projection introduced as the most advanced 3-D tool which has the ability to create 3-D images in vacant spaces. Through the use of holographic projection the viewer is able to see something, which does not exist in reality, in a virtual 3-D state. One of the advantages of using this projection in reconstruction approach is that it gives the audience the opportunity to remember certain sections of the building, or a historical event through generating a virtual shape in real dimensions. In other words, by deploying this lighting technology, physical and virtual aspects of the facade of historical buildings are integrated and renovation is done. Another advantage of holographic projection is that it enables the architects, artists, and restorers to offer the audience the opportunity to see the historical aspects of a building or monument, which do not exist any longer. Applying this technology in the field of reconstruction and architecture recommended in this study as a future work.

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APPENDIX

Questionnaire

Please choose the appropriate response.

1- Which type of lighting creates a better realistic view of the building and the surrounding spaces?

Lighting by 3d projection mapping ☐ Lighting with other tools ☐

2- When did you pay more attention to the details of historical facade?

During the exhibition ☐ other nights ☐

3- In your opinion how was the quality of projecting to display realistic images on the historical building?

High quality ☐ Normal ☐ low quality ☐

4- Would you please give your opinion about these items?

Color of images...

Edge of images..

Clearance of images...

5- Does this artistic exhibition represent the images matched with the facade of building?

Yes ☐ No ☐

6- How was the quality of exhibition by 3D projection mapping from the building facade in the exhibition?

High quality ☐ Normal ☐ low quality ☐

Your approximate distance from the building facade in the exhibition:

....

B) Please indicate how strongly you agree or disagree with each of the statements below. Please circle the number that best corresponds to the strength of your belief.

1. Disagree 2. Slightly disagree 3. Neither agree nor disagree 4. Slightly agree 5. Agree

1- The exhibition on the historical facade and created some images on the facade with 3D projection mapping which doesn't exist in reality at night seems to be close to the reality as far as colors are concerned.

① ② ③ ④ ⑤

2. The exhibition by 3D projection mapping can increase the perception and information of the audience about the space s/he is exposed to.

① ② ③ ④ ⑤

3. The facades of historical building during this exhibition were more effective.

① ② ③ ④ ⑤

4. The historical facade during the exhibition at night can help historical buildings to create a better connection with the surrounding or homeland.

① ② ③ ④ ⑤

5. This exhibition at night can make this square special or unique.

① ② ③ ④ ⑤