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Emerging Technologies in Architectural Visualization: Implementation Strategies for Practice

Nethra Mettuchetty Ram Mohan

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EMERGING TECHNOLOGIES IN ARCHITECTURAL
VISUALIZATION - IMPLEMENTATION
STRATEGIES FOR PRACTICE.

By
Nethra Mettuchetty Ram Mohan

A Thesis
Submitted to the Faculty of
Mississippi State University
in Partial Fulfillment of the Requirements
for the Degree of Master of Science
in Architecture
in the School of Architecture

Mississippi State, Mississippi

May 2003

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Nethra Mettuchetty Ram Mohan

2003

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VISUALIZATION - IMPLEMENTATION
STRATEGIES FOR PRACTICE.

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Representation has always been a critical component in architectural practice and representational techniques have been evolving over time. The relatively recent advent of the digital media is revolutionizing architectural representation. Digital representation techniques are proving to be a more effective means of communicating the design to the client and the collaborative project team.

The techniques are advancing so rapidly that it is becoming increasingly difficult to keep in pace with the digital acceleration and utilize these representation techniques in architectural practice. There is a wide difference between what is possible using digital architectural visualization and what is implemented in practice. The research explores the extent of utilization of these digital representation techniques and the challenges they pose in practical implementation.

Employing a logical approach to selectively implement this digital procedural change in representation would help in realizing the strategic benefits of these rapidly progressing techniques.

DEDICATION

To my family

ACKNOWLEDGEMENTS

I wish to extend my gratitude to all those who have helped me shape this research through insightful discussions and support. My sincere gratitude to Dr. Larry Barrow for his excellent support and guidance throughout the research process. My sincere thanks to Laurie Livingston for her invaluable support with the research and her patience in correcting all my grammatical errors. My thanks are due to my committee member Tim Nichols, who had taken time from his busy architectural practice and provided insights into the practicality of the profession.

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CHAPTER I INTRODUCTION

Representation is an age-old tradition that had been in vogue from as early as the Stone Ages, when the drawings in the caves and hieroglyphs were highly detailed depictions of people's everyday life. Representation techniques have been evolving with time and many novel mediums of expression are being explored. The fairly recent computer revolution (Circa late 1970's) introduced the concept of digital visualization and representation. These digital visualization techniques are showing rapid progress in offering diverse means for artistic expression.

Architectural representation has been evolving as a critical component in architectural practice since the Middle ages (Circa 12th century). Many different tools and techniques of architectural representation have been developing, helping in better communication of design ideas. The advent of digital visualization and technological acceleration has resulted in tremendous advancements in the field of architectural representation. This moment of change requires a reflection on the ideas and problems that describe this condition, as well as a critical discourse on the role and possible capacities of architectural representation in relation to the modifications produced by the digital revolution.

The research question is as follows

How effectively is the practice of architecture utilizing advancements in digital techniques for architectural visualization and representation?

Though digital visualization techniques are showing improved capabilities and great potential for use in architectural visualization, the extent of their utilization in architectural practice is less compared to their potential benefits. These digital techniques are improving so rapidly that it becomes rather difficult to keep in pace with their advancements. The fast pace of developments creates a huge knowledge gap among architects in practice, which might result in confusion and lack of assertiveness in the deployment of digital techniques.

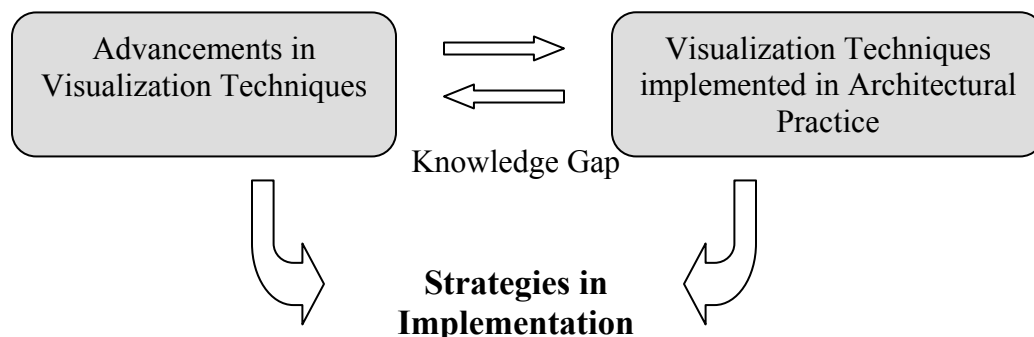


Figure1.1: The Research Problem

I am studying the growth in capabilities of digital visualization techniques and their current utilization in architectural practice, to explore their effectiveness and barriers

in their implementation. This study will help in understanding the potential benefits and challenges posed in implementing these ever progressing technologies.

In this information age, researching and preparing for the future, strategically forecasting and understanding the potentials of the growing technologies is crucial to the success of any architectural practice. The rapid progression of technology creates a growing need to be receptive to a change. Failure in understanding and strategically implementing these changes might lead to denigrated marketing and the firm might lose its clientele. These might make an architectural practice lose its competitive edge in the market or leave them obsolete.

A clear comprehension of the potential benefits of these digital technologies, aids in reducing the knowledge gap and helps in making significant decisions in implementation. Understanding and using the correct strategies for successful implementation, plays a significant role in the economic growth and success of any architectural practice. This study also gives a glimpse of the barriers to the entry of technology in architecture and opens up avenues for future developments.

The scope of this research is restricted to the study of digital visualization more as a representation technique for communicating design through out the design process rather than as a tool to design. It aims at studying the growth and development of digital visualization in the field of architectural representation and the possible roles it can take.

The research explores the extent of utilization of digital representation techniques in architectural practice in comparison to the actual potential for utilization. Chapter II: Methodology gives a detailed description of the methodology followed for research

namely the qualitative normative from case studies and surveys. In Chapter III we will take a look at the history and background of architectural representation practices and techniques. The growth and developments in the digital arena relating to the architectural field are studied in Chapter IV. This chapter gives an overview of the developments in computer aided drafting tools, representation techniques and the growth of the hardware and software industries. Chapter V talks about the current context in architectural firms, the techniques currently adapted and the research that is being undertaken in the architectural research centers.

Chapter VI is a case study of HKS Inc, an architectural firm which is quite progressive in its use of digital representation techniques. In Chapter VII we take a look at the survey results showing the current trends of visualization firms specializing in architectural visualization. Chapter VIII is an account of my personal experience in using the high end digital visualization tool, Maya. These evidences are analyzed and the implementation strategies are derived in Chapter IX. Chapter X gives an account of the conclusions derived from this research.

We proceed with the hypothesis which is stated as follows:

Digital visualization techniques are showing rapid progress and great potential for use in architectural visualization. Implementation of these techniques is quite challenging, impeding their penetration into the practice of architecture.

CHAPTER II

RESEARCH METHODOLOGY

A qualitative approach was used in this research via Case Studies, Interviews and Personal Experience. Surveys were also a part of the research, where both quantitative and qualitative methodologies were implemented.

The initial research started with a general study of visualization practices in architecture. From the broad topic of visualization I narrowed my research to concentrate on digital techniques used in architectural representation. The history and current context were studied through literature review from books, journals, thesis dissertations and websites. The interviews of visualization experts and technical professionals, who are working in designing the hardware and software for visualization, gave an insight into the present market situation in architectural representation.

My internship at HKS Inc facilitated a detailed case study of the firm and interviews with the project managers, designers and visualization architects involved in architectural projects. Further details were gathered through sending a questionnaire to the firm through email. The Siggraph convention at San Antonio in July 2002 provided a good exposure to the emerging technologies in computer graphics that had a potential for use in architectural representation. Many other research projects in the field were studied through the websites of research labs and their research papers. .

Primary Evidences on the present business models of visualization firms were collected through an online survey. This survey was conducted at the Digital Research and Imaging Lab at Mississippi State University through November 2002. A questionnaire was sent through email to a few prominent architectural visualization firms which are trying to embrace digital techniques for architectural representation. The questionnaire concentrated on their infrastructure, location and strategies for practice. Reference is also made to many websites and books that have statistics and articles about the present trends of representation in architectural practice.

My personal experience at using a high-end tool for visualization and representation played a significant part of this research. Alias Wavefront Maya was the software used for exploration in this research.

The different enquiries, tasks, personal experiences and surveys were organized to study the complexities faced by architects in the practical field to implement the advancements in architectural representation. Issues and answers to these complexities were derived through analysis of these studies and looking at the trends in development in the architectural visualization field.

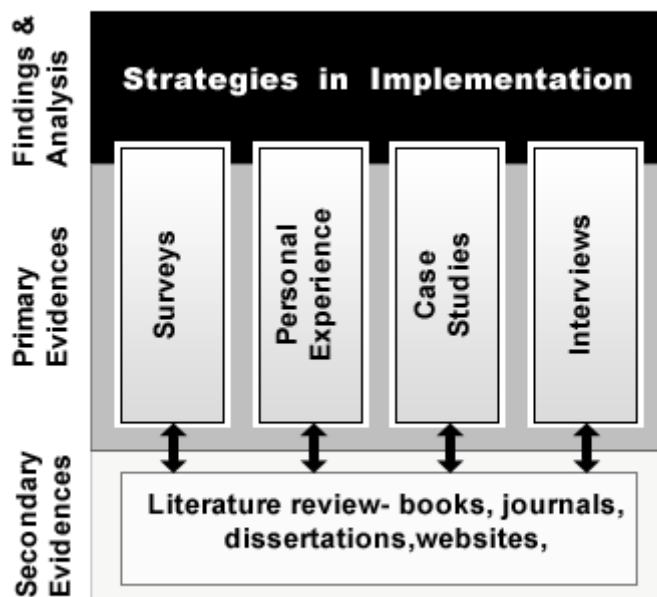


Figure 2.1: Research Framework

CHAPTER III

HISTORICAL BACKGROUND

Architectural representation has always been an artistic activity where the architect himself or an expert in visualization and representation takes up the task of depicting how the building will look when it is built. This served as an important tool of expression to explain the design to the client, who was not trained to visualize from plans and elevations and to the others involved in the project. Wooden models and hand drawn perspective renderings were used traditionally for representation of architectural design. However, not many architects were skilled at perspective techniques. They started hiring “specialists” to meet their representation needs. In this chapter we will take a look at the history of architectural representation and its transformations over time.

In the early Middle Ages, prior to the thirteenth century, only a very few drawings were done. The prevalent types of architectural representation were in the form of plan drawings and detailed full-scale representative physical models. These representations were done mostly on parchments, wooden planks or sheets of fresh plaster that were disposed off after the structure was built. By the Late Medieval period (Circa 13th century) drawings for façades and details were drawn, which were mostly orthographic projections.

Perspective drawings, which were more descriptive of the buildings, were developed during the Renaissance period. The early beginning of perspective theories can be traced back to the Italian Renaissance period, when Loene Battista Alberti (1404-72) was the first to codify the system of one point perspective in a written treatise Della Pittura. His theory of the perspective system relied heavily on the sciences of medieval optics and classic geometry. He realized perspective drawings were a better means of communicating the design to the client than just using plans and verbal descriptions.

Leonardo da Vinci (1452 – 1519) was fascinated by Alberti's work and he along with Bramante introduced the bird's eye perspective for architectural designs. These perspective drawings gave the architect another level of freedom to visualize and communicate his design.

Michelangelo Buonarroti (1475 -1564) was another influential architect who revolutionized and devised an entirely new approach to representation. He preferred to make clay models of buildings rather than perspective drawings. For his most important commission at St.Peter's, Michelangelo used detailed drawings and elaborate models for representations, some of which were done in full scale using timber.

During the 1740's the Italian etcher, archaeologist and architect Giovanni Battista Piranesi developed his own style of creating images adding imagination to the discoveries of the archaeologists. His output was phenomenal and his extraordinary skills helped imagine and visualize the grandiose architecture from discovered ruins. Figure 3.1

depicts Piranesi's drawings for his 'Prisons' series, which were an unrestrained exercise in architectural fantasy.¹

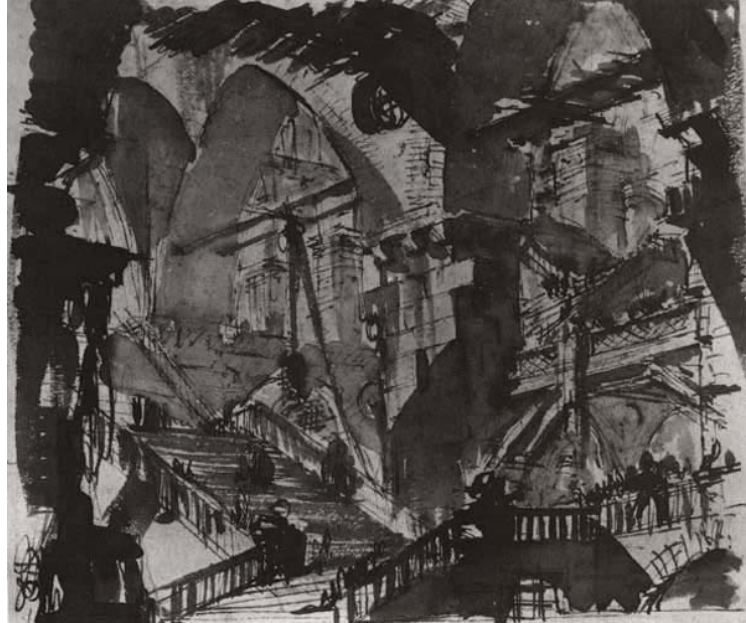


Figure 3.1: Rendering of Piranesi

Source: Masterpieces of Architectural Drawing, Abbeville press publishers, New York 1983

The Neo Classical designers of the early Victorian period, CR Cockrell and Harvey Lonsdale Elmes, exhibited a mastery of classical proportion and detail. The drawings were accurately and delicately delineated with a convincing rendering of light and shadow.

¹ Helen Powell and David Leatherbarrow, Masterpieces of Architectural Drawing, Abbeville press publishers, New York 1983

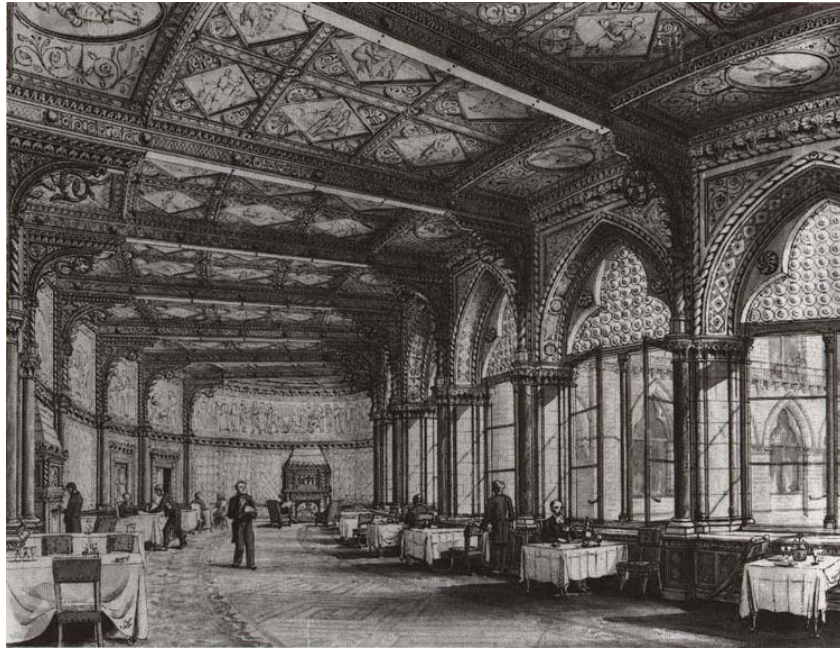


Figure 3.2: Rendering by George Gilbert Scott

Source: Masterpieces of Architectural Drawing, Abbeville press publishers, New York 1983

During the late nineteenth century when architects began to explore different techniques and styles a few architects like Louis Sullivan, who must be reckoned as one amongst the best draughtsmen of the period, practiced the use of a soft pencil for the representation of architecture.

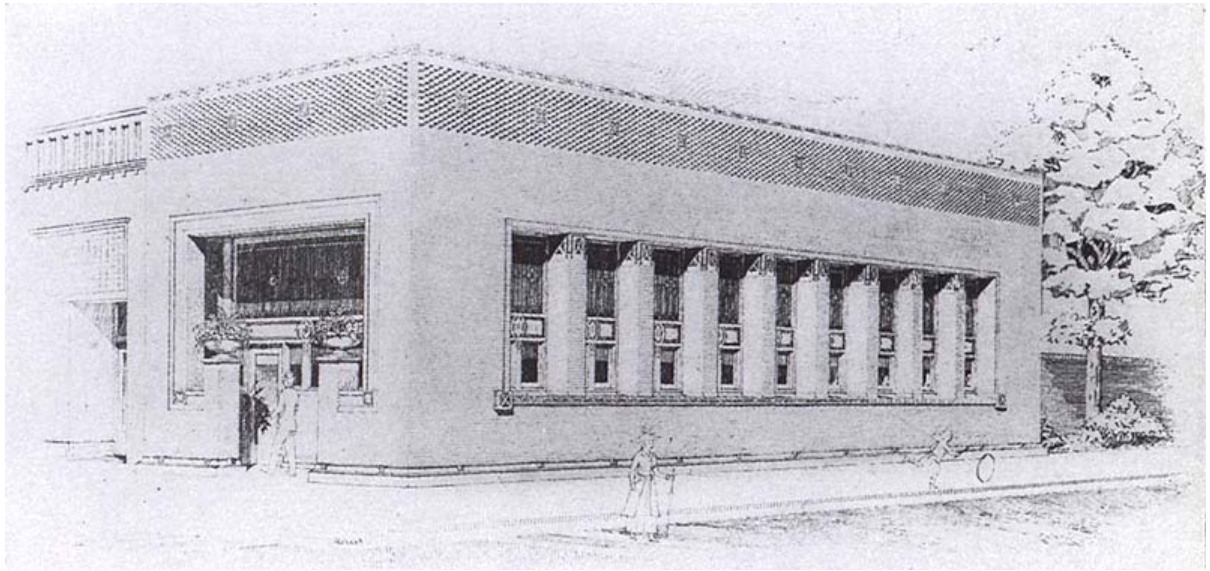


Figure 3.3: Rendering by Louis H Sullivan-1913
Source: The Function of Ornament, Library of Congress, 1986

The concept of architectural design competitions gained importance during the nineteenth century, which called for architectural presentation drawings. These competitions greatly encouraged the submission of perspective drawings along with plans elevations and sections. The perspective drawings not only served the purpose of convincing the client but were also exhibited and published in magazines. These drawings were done to a greater detail with convincing environmental effects giving a glimpse of how the building will look when it is built.

Figure 3.4 shows a competition entry for the National Gallery, London by Matthew Digby Wyatt. The rendering depicts Wyatt's use of convincing atmospheric perspective to lend an air of authority and visual coherence to his designs. These

representations offered a concrete evocation of architectural ‘mood’ through the imitation of different kinds of architectural features.²



Figure 3.4: Rendering by Matthew Digby Wyatt

Source: Masterpieces of Architectural Drawing, Abbeville press publishers, New York 1983

By the end of the nineteenth century perspective drawings were mandatory for almost all competition entries requiring group of specialists called the “ghosts” or “renderers” for doing the perspective drawings. Though the works of these “specialists” were typically left unsigned, many architects had a particular preference for a few renderers based on their speed and accuracy.

In a few years the judges of competitions made a strong reaction against perspective drawings, arguing that perspective renderings were very stylish and

² Helen Powell and David Leatherbarrow, *ibid.*

exaggerated, distracting the attention from the real merits of design. In 1900 the Royal Institute of British Architects decided that perspectives should not be included in design competitions.³ In most other places renderings were still in vogue and were developing newer techniques.

The architectural practice changed with time and technological developments and by the nineteenth century the role of the architect became more of an administrator than it had been before. The renderers developed as a group of specialists who were architects doing freelance work on architectural perspective drawings, elevations and renderings. They did not concentrate on designing buildings, or at least they did not work in their own name. In England this covert designing was known as ‘ghosting’ while the preparation of perspectives was known as ‘taking in washing’.

For young draughtsmen who could not set up their own practice this served as a good source of independent employment. They developed their own styles in rendering perspectives. They could, with their skill in composition, lighting and foliage make an otherwise mediocre design look good.

This community of renderers grew as a separate group of specialists and established a place for themselves in the architectural profession. They extended their services to not only to the architects who weren’t very comfortable with rendering but also to the leading architectural practices, who started employing these professionals for their speed and accuracy. This practice continued well into the 20th century and renderers were utilized as a separate class of “specialist” practitioners.

³ Helen Powell and David Leatherbarrow, *ibid*

SUMMARY

- Architectural representation came into practice during the Middle Ages (Circa 12th century) when the architect sketched plans and made full scale models of the details in the buildings.
- Architectural perspective drawings were introduced during the renaissance period. (Circa. 1452) These were done by the architects themselves to aid communication of design.
- The increase in architectural competitions and the need for detailed visualizations for communicating the design added to the popularity of perspective drawings and renderings (Circa late 19th century)
- Different techniques of rendering were introduced adding realism to the perspective drawings
- Architectural practices that did not have the capability to do detailed perspective renderings started outsourcing their visualization and representation needs to specialists who were popularly known as “ghosts” or “renderers”.
- The “renderers” who were architects, developed as a specialization in architecture doing renderings for perspective drawings and elevations.

This group of specialists had to go through a major change in their process and style of rendering with the advent of the digital revolution. We will see the growth and developments of digital technology in the next chapter.

CHAPTER IV

GROWTH AND DEVELOPMENT OF DIGITAL TECHNOLOGY

A change in technology typically results in the development of new skills and methodology of work. Computers have brought a sea change in the practice of architecture. It took a few decades for the architect to overcome the psychological and economic barriers in order to employ these digital means in practice. In this chapter we will look into the introduction of computer aided tools for drafting followed by the developments in computer graphics which played a significant role in architectural representation. In Section 4.3, we will look at the growth and developments in the field of hardware and software, which facilitated the implementation of these digital techniques.

4.1 DEVELOPMENTS IN CADD

Computer aided drafting has become ubiquitous in almost all architectural offices at present. However, it wasn't an easy change from manual to digital means. In this section we will see a brief history of computer aided design and drafting and the difficulties faced by the architects to apply these digital technologies for drafting.

The introduction of CAD can be traced back to the 1960's when a few adventurous students (notably from MIT in Boston & UCLA in Los Angeles in the United States; Edinburgh, Strathclyde, and Cambridge Universities in the United Kingdom and the University of Sydney in Australia) experimented with using computers for architectural design.⁴

In 1960, Ivan Sutherland used the TX-2 computer produced at MIT's Lincoln Laboratory to produce a project called "sketchpad", which is considered the first step to CAD industry.⁵ Sketchpad pioneered the concepts of graphical computing, including memory structures to store objects, rubber-banding of lines, the ability to zoom in and out on the display, and the ability to make perfect lines, corners, and joints. This was the first GUI (Graphical User Interface) long before the term was coined.⁶

Computers had been developing very fast from the plug board and punched card system to a keyboard and screen mechanism. In the late 1960's the first commercial computer- aided drafting software was introduced in the market. But the cost of a computer was so high that it was not affordable by the architectural firms either large or small. CAD applications were chiefly used by the large automobile, aerospace and

⁴ Antony Radford, Garry Stevens, CADD made easy, McGraw- Hill, 1987

⁵ The history of CAD, retrieved March 13,2003 from <http://mbinfo.digitalrice.com/CAD1960.htm>

⁶ Sketchpad: The First Interactive Computer Graphics, Ph.D. Thesis, 1963 -- Mass. Institute of Technology, retrieved March 13,2003 from <http://www.sun.com/960710/feature3/sketchpad.html>

electronics engineering firms. These firms had projects with a large budget which could afford the expenses of the software and hardware necessary for implementing computer aided tools.

By the mid 1970's there were significant improvements in the CAD software; some higher functions were possible rather than just simple drafting. A few very large architectural firms were beginning to try CADD tools. But the recession of 1974 further dampened the situation and architects were turning more skeptical about the use of CAD⁷.

The use of computer aided drafting systems took off during the late 1970's with the advertisement of the vendors and the press. The heavy competition between the vendors made them implement steady improvements in the software utilities as well as reduced costs. Menu driven programs came into practice freeing the architect from learning complex commands and routines.

The advent of personal computers in the 1980's was another milestone for the immersion of CAD into architecture. The graphical user interface based on icons, pull down menus and dialog boxes was developed where a mouse was used to point and click. Many architectural firms started using the computer though their main use was for word processing and spreadsheets. A survey in 1985 reveals that only 10 percent of architectural firms were using the computer for computer aided designing and drafting systems.⁸ A few digital visualization applications were also developed like TOPAZ and

⁷ Antony Radford, Garry Stevens, CADD made easy, McGraw- Hill, 1987

⁸ Antony Radford, Garry Stevens, CADD made easy, McGraw- Hill, 1987

RIO but they were used mainly for the broadcast and graphics industry and were used minimally in architecture.⁹

Complexities in implementation:

While paper formats were easy to work with for many reasons, the strength of digital formats mainly their speed, accuracy, editing ability and reusability was recognized. However the architects still faced a few difficulties that prevented the deployment of computer aided drafting in its initial stages. The architect's lack of knowledge regarding technology tools was the main factor. Though the use of CAD was published in many architectural journals, architects were not comfortable using computers. They suspected the capability of technology with regard to architectural practice. CADD was mostly associated with standardized structures and elements. Architects, being creative professionals, felt that it was not the right tool for them. They felt an antipathy towards mechanical kind of drafting using a keyboard and mouse as opposed to the freedom of pen and paper.

Most architectural firms of that time were small to medium sized who could not afford the cost of hardware and software. Only a few very large firms could think about experimenting with the technology. The other industries like the automobile, aerospace and electronics industries could implement CADD with much ease because the time and money they invest on one product can be used for many hundreds and thousands of items, which is not the case in the practice of architecture.

⁹ Curtis B Charles and Karem M Brown, Multimedia Marketing for Design Firms, John Wiley and Sons Inc, 1996

The complexities and slow speeds of operation of the initial CADD programs impeded their penetration into the market. The learning curve was very steep and it was rather difficult to learn and adapt to the new medium. Also, the output facilities were very expensive and not of very good quality. Hence the use of CAD was very limited in architecture.

Additionally, the majority of senior managers in architectural firms did not have a good understanding of computers. They were unwilling to adapt to the new technologies. This hierarchical setup and mental block was a major barrier to CAD technology adaptation in architecture.

In the early 1990's, many architectural firms started using CAD for their drafting and plan production purposes. Additionally, young architects were entering the work force with a higher level of skills and comfort with computing technology. The speed and ease of editing construction plans saved time thus allowing higher firm profits.



4.2 DEVELOPMENTS IN COMPUTER GRAPHICS

Contemporary to the developments in CAD were the developments in computer graphics, which had a significant influence on architectural visualization. Computer tools came into the field of art around the late 70's, but their use was very minimal. Later with the growth and development of hardware, which will be discussed in the next section, newer visualization techniques evolved. The entertainment industry was one of the pioneers in using most of these digital techniques. Gradually these techniques entered the architectural visualization field, giving the architect more potential to effectively express

his/ her design ideas. In this section, we will take a look at the growth and developments in digital techniques that have a significant potential in architectural visualization.

The comparison (See Table: 1) was developed from excerpts collected from the electronic version of the magazine “Computer Graphics World” (C.G.W). CGW published the developments in each field as a series of issues, while celebrating the 25th anniversary of the magazine. The table compares the retrospective of developments in digital techniques in the fields of computer art, movie industry and architectural visualization. This comparative study helps us understand the stage by stage improvements in the digital graphics field and how each field had a influence on the other, sharing techniques and innovations according to the specialized necessity.

Table: 1 Retrospective of Computer graphics in Computer Art, Movie and Architecture.

Period	Computer Art ¹⁰	Movie ¹¹	Architecture ¹²
Late 70's	<p>Digitizing a hand drawing and then modulating using computers to generate complex variations of drawings which would be extremely difficult to prepare by hand.</p> 	<p>computer graphics weren't used much.</p>	<p>Using a Calma interactive graphics system based on a Data General Eclipse S-200 computer. The graphical database enables street views with varying levels of details.</p> 

¹⁰25 Year Retrospective, Retrieved July 13,2002 from http://cgw.pennnet.com/Articles/Article_Display.cfm?Section=Archives&Subsection=Display&ARTICLE_ID=132487&KEYWORD=retrospective

¹¹Barbara Robertson, Movie Retrospective, Retrieved July 13,2002 from http://cgw.pennnet.com/Articles/Article_Display.cfm?Section=Archives&Subsection=Display&ARTICLE_ID=148548&KEYWORD=retrospective

¹²Jenny Donelan, Architecture Retrospective, Retrieved July 13,2002 from http://cgw.pennnet.com/Articles/Article_Display.cfm?Section=Archives&Subsection=Display&ARTICLE_ID=144606&KEYWORD=retrospective

Table: 1 (continued)

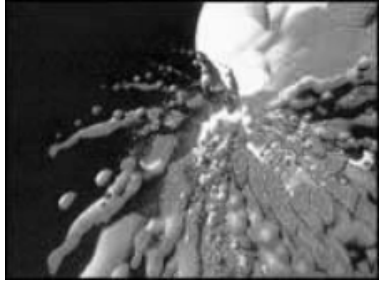











Period	Computer Art	Movie	Architecture
Early 80's	<p>Experimental techniques- applying random displacements and geometric and organic shapes created on the computer, redefine abstract art with a series of fluid amorphous shapes. Editing photographs using a digital paint system.</p> 	<p>Introduction of computer graphics into movies. Digital Productions creates CG spaceships, planets and high tech hardware that are integrated into live-action scenes.</p> 	<p>Introduction of software systems tailored to architectural users. Especially used in fast track construction.</p> 
Late 80's	<ul style="list-style-type: none"> - Development of raytracing techniques. - Realistic and richly textured reflective surfaces. -use of displacement mapping and surrealistic graphic effects were coming into fashion. 	<ul style="list-style-type: none"> - Introduction of digital 3d characters to create superhuman effects - Animation software running on SGI's. storyboards are scanned into paint programs and edited. 	<ul style="list-style-type: none"> -Architectural software becomes a necessary tool for firms hoping to win large scale building design bids. - Radiosity algorithms for creating realistically lit scenes and sophisticated scenes using detailed texture maps. -Architectural renderings and animated fly through's were developing 

Table: 1 (continued)

Period	Computer Art	Movie	Architecture
Early 90's	<ul style="list-style-type: none"> - creative imaging gained importance - a new breed of artist who learned to draw on the computer rather than in traditional art classes. - representation of visual adventures in a fractal world, which explored relationships between art, science and technology. 	<ul style="list-style-type: none"> - motion capture and studio rotoscopes are attempted to achieve special visual effects. - Computer graphics characters as well as animatronics were started to be used in lively ways. 	<ul style="list-style-type: none"> -computer aided landscape design tools were evolving. - photomontage- combining architectural rendering and videoimages. - the concept of reflection in glass façade renderings was becoming common. 
Late 90's	<ul style="list-style-type: none"> – players could move about a 3D model of the building which had a lot of decorative textures and objects. -the concept of digital hypnosis by tuning into a person's biofeedback in an attempt to enhance the experience of immersion in a virtual environment. -Refining the reflective and refractive capabilities of software to raise graphics realism. 	<ul style="list-style-type: none"> - introduction of 3D lead characters in live action movies. - custom software to create, animate and render fur and hair. - dynamics and particle systems to create digital effects -background artists painted on 2Dplots of 3D scenes- information about each brushstroke was stored and later applied to positions in 3D space. - use of non photorealistic and surrealistic effects. 	<ul style="list-style-type: none"> -software have increasingly started implementing global illumination techniques. - huge sizes and complex shaped buildings were visualized and built using computer aided design tools. - visualization tools are increasingly used for collaborative design process . - architectural tools begin to incorporate a fourth dimension – time. 

These developments clearly indicate the rapid progression of technology and the innovative techniques and rendering styles that emerged from these advancements. The entertainment industry is the forefront of experimenting and implementing these innovations. Techniques which were new in the movie and the games industry would be utilized in the field of architecture in a period of about 5 years. Though lagging behind, the architectural visualization techniques are building up at a steady pace, trying to emulate the entertainment industry.

4.3 DEVELOPMENTS IN HARDWARE AND SOFTWARE

In this section we will take a brief look at the growth and developments of the software and hardware industries relating to architectural practice that have opened up new potential for implementing digital visualization techniques.

The rate of change and the direction of change in the computer industry are becoming increasingly difficult to predict. Digital tools and programs are getting outdated very rapidly and new innovations and improvements are burgeoning keeping the momentum of the industry high and active. The capabilities of hardware and software applications are improving exponentially and their prices are dropping down to affordable ranges.

The rapid pace of developments in the computer industry results in entire generations of software and hardware becoming obsolete by the time an architectural project is completed. Architects are trying to flow with the tide appraising their use of technology and trying to keep in pace with the current developments.

During the early days of the computer revolution one vendor supplied the hardware, software and set the standards. The price of the software depended on factors like size of the market, size of the machines and the functions it could perform. The architectural market being very small resulted in the cost of the software being high for the functions they could perform.¹³ Currently, we see a tremendous increase in processing speeds, memories and better performances. The hardware is developing at such a fast pace that the processing speed is doubling every couple of years.

Gordon Moore, Chairman Emeritus of Intel Corporation made his famous observation in 1965, just four years after the first planar integrated circuit was discovered. Moore observed an exponential growth in the number of transistors per integrated circuit and predicted that this trend would continue. Through Intel's relentless technology advances, Moore's Law, the doubling of transistors every couple of years, has been maintained, and still holds true today. (See Figure 4.1) ¹⁴

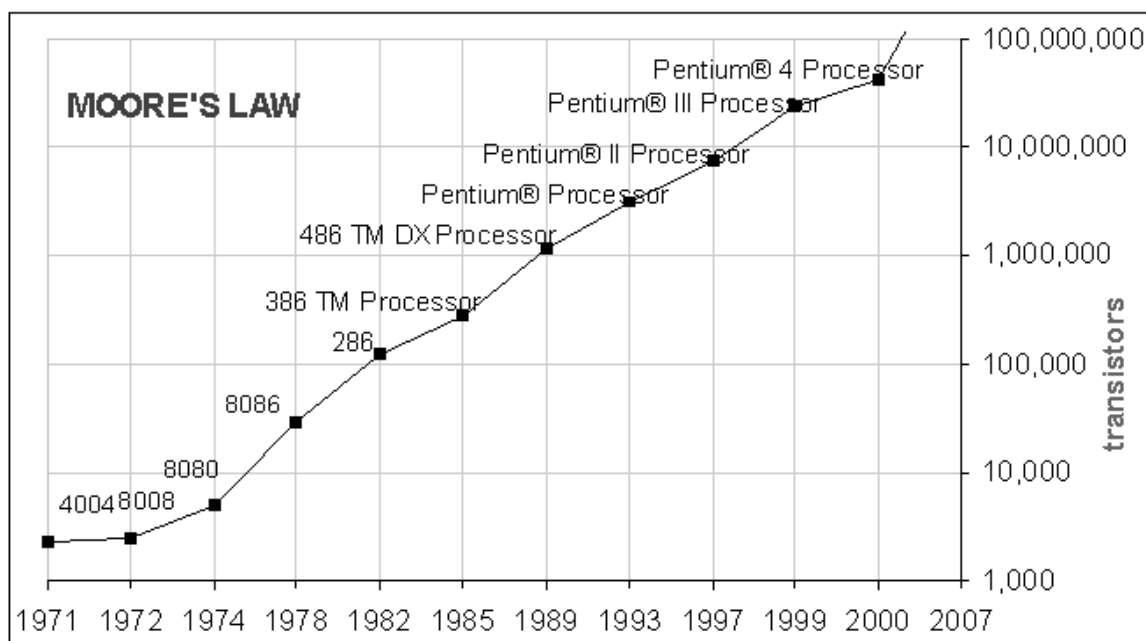


Figure 4.1: Moore's Law

¹³ Antony Radford, Garry Stevens, CADD made easy, McGraw- Hill, 1987

¹⁴ Moore's Law, Retrieved January 20,2003 from <http://www.intel.com/research/silicon/mooreslaw.htm>

Retrieved January 20,2003 from <http://www.intel.com/research/silicon/mooreslaw.htm>

Andy Grove, former Intel CEO, predicted that Intel would ship a processor with one billion transistors in 2011, which is in line with Moore's Law. Other industry experts see silicon technology reaching its physical limits around 2017. The implications of the continued viability of Moore's Law are profound. In addition to the fact that our increasingly computerized economy will become even more productive, other technologies such as voice recognition, virtual reality, and artificial intelligence begin to appear possible. And speaking of profound, if Moore's Law were to somehow survive on into 2030, the processor would then surpass the computational power of the human brain.¹⁵

Another significant improvement in the evolution of hardware is the development of the graphics accelerator. The graphics accelerator is one of the main hardware components responsible for modeling and rendering in real-time with greater realism. The first shading accelerators of the mid 1990's could generate 300,000 polygons/sec. We now see an increase in performance at an exponential rate of 25X every 3 years. This is an astounding achievement, especially when compared to the 5X rate of performance increase for the CPU.¹⁶(See Figure 4.2)

¹⁵ Barrow. Larry.R, IT and the Future, "Cybernetic Architecture, Process and Form -The impact of information technology" Doctoral Dissertation, Harvard Design School, 2000.

¹⁶ Tim Lewis, The accelerating Visual experience; Retrieved January 16,2003 from <http://cadinfo.net/editorial/Tim%20Lewis#Tim%20Lewis>

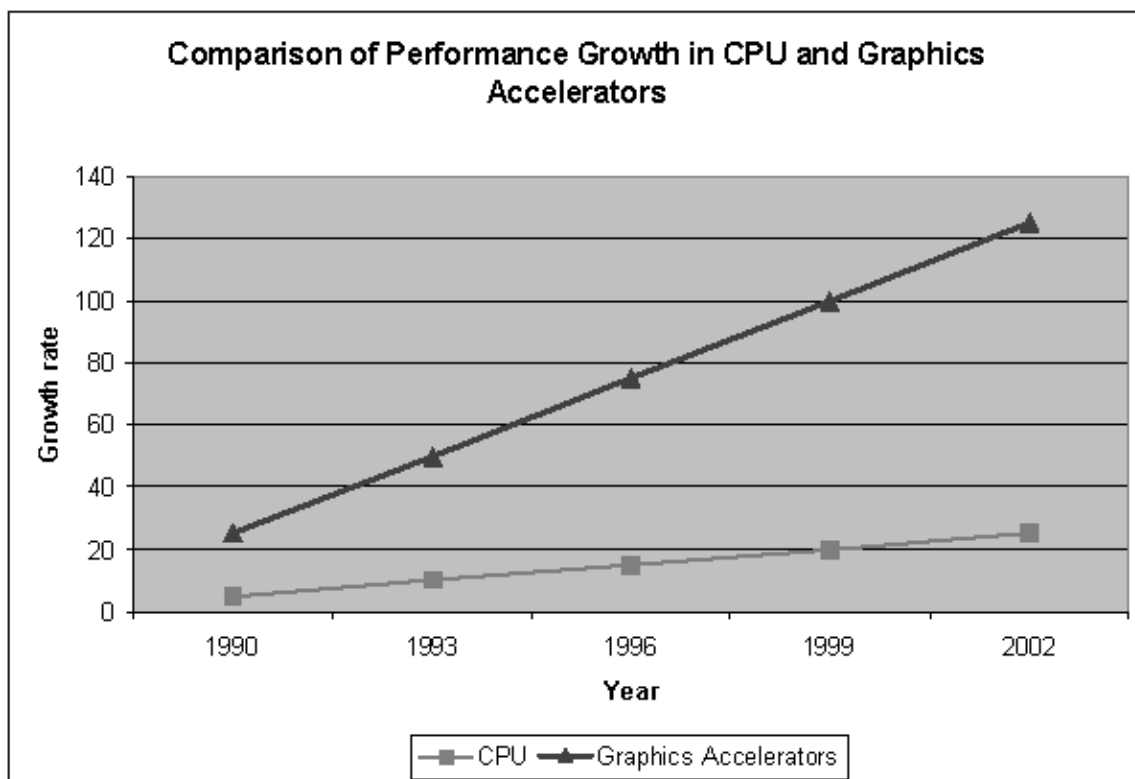


Figure 4.2: Comparison of Performance Growth in CPU and Graphics Accelerators

According to Tim Lewis¹⁷, a significant factor affecting the growth of hardware is the consolidation of competitors in the industry. For instance the number of companies who were developing graphics chips was more than a fifty around the late 90's. But now it is reduced to three or four companies that rule the market. This competition among very few key players is beneficial to the consumers in terms of rapid product innovation, price sensitivity and high quality.

ART VPS Ltd,¹⁸ headquartered in UK is a leading manufacturer of 3D rendering accelerators which can create images of true realism in significantly less time. A

¹⁷ Tim Lewis, *ibid*

¹⁸ Advanced Rendering Technologies, <http://www.art-render.com/>

rendering that takes about an hour and 40 minutes in Maya¹⁹ software rendering can be done in around 3% of that time using the latest renderers PURE P1800 and RenderDrives. (See Figure: 4.3)




	<p>PURE P1800 1024 x 1024 pixels: 4 minutes 53 secs</p>
	<p>RenderDrive RenderDrive RD5000 1024 x 1024 pixels: 2 minutes 41 secs.</p> <p>RenderDrive RD3500 1024 x 1024 pixels: 3 minutes 39 secs.</p>
	<p>Maya Software Rendering 1024 x 1024 pixels: 1 hour 40 minutes</p>

Figure 4.3 Comparison of rendering speeds

Source: Advanced Rendering Technologies Retrieved Nov 15, 2002 from <http://www.art-render.com/>

¹⁹ Alias Wavefront Maya

The “Turing Test” is a popular topic in the field of artificial intelligence which suggests “We can know that machines have become intelligent when we can not distinguish them from human, in free conversation over a teletype”²⁰. Tim Lewis²¹ observes that to achieve such realism as to pass this test we have to render each frame at the rate of 1/25th of a second which is at present not achievable.

There is usually a time lag between a hardware up-grade and its implementation in software applications. This opens up a programming gap. The designers of software observe how a particular piece of hardware gains popularity in the market and then implement these advancements in the design of software. For instance the 64- bits CPU’s were introduced by Intel and AMD in 1990’s but the latest CAD news²² shows that it is still not utilized by any of the CAD software.

We see that the Engineering fields are progressive in their utilization of hardware developments. NEC's new SX-7 vector supercomputer uses 32 CPUs and 256GB of memory, and costs more than US\$100 million; prices start at US\$2.2 million. The company expects to sell more than 20 per year to automotive and aerospace companies.²³

²⁰ Tim Lewis, The accelerating Visual experience; Retrieved January 16,2003 from <http://cadinfo.net/editorial/Tim%20Lewis#Tim%20Lewis>

²¹ Tim Lewis, *ibid*

²² u p F r o n t . e Z i n e Issue #326 | Retrieved February 4, 2003 from <http://www.upfrontezine.com/upf-326.htm>

²³ Computer News Summaries – CNET Retrieved October 22, 2002 from <http://www.upfrontezine.com/upf-314.htm>

We cannot expect such a utilisation in the field of architecture mainly due to the cost concerns and the size of the projects. Even the large firms working on bigger projects cannot afford such facilities. However, a few facilities such as online render farms are developing, that are aiding architects, freelance graphics animators and visualization specialists who cannot afford to set up a render farm. These renderfarms have the infrastructure to render complex scenes and animations in significantly less durations.

ResPower , Inc. was opened up in March 2002 and is serving the rendering needs for clients throughout the world. Users log on to the website and start rendering as if they are right there in their own facilities. The current infrastructure of ResPower, Inc shows 134 Computers, 230 GHz - 512 MB RAM per Ghz- Fiber, T1, Cable Internet - Gigabit Switched Internal Network For Servers - 100 Megabit Switched and Segmented Internal Network For Render Nodes - UPS for every computer - Zip, DVD, CD-Rom, etc. They charge in hourly rates and their present rates are about U.S.\$ 0.50 per hour for Lightwave and 0 U.S.\$ 0.75 per hour for 3DS Max and Maya.²⁴

The dramatic developments in hardware have made it feasible for the architects to use computer graphics for their representation needs. However, many of the software being used in architectural representation have been developed for the entertainment type of industry resulting in higher costs and steeper learning curves.

California based M2 market Research says the elite 3-D animation market shrunk from \$146 million in 2001 to \$133 million in 2002, and it will grow on average by just

²⁴ Respower, Retrieved Nov 15,2000 from <http://www.respower.com>

one percent through 2007. Meanwhile, less traditional 3-D animation sectors – including architecture and industrial design will average 23 per cent growth.²⁵

Likewise computer graphics is becoming increasingly popular in architecture and the developments in software show frequent upgrades. Each upgrade in a software addresses many shortcomings and adds a few new significant functionalities. It takes a couple of versions for the software to mature into a more usable product. This is evident from the frequent releases of the higher versions. There is also a steady decrease in the price of the software as the market widens and reaches more people. (See Figure: 4.4)

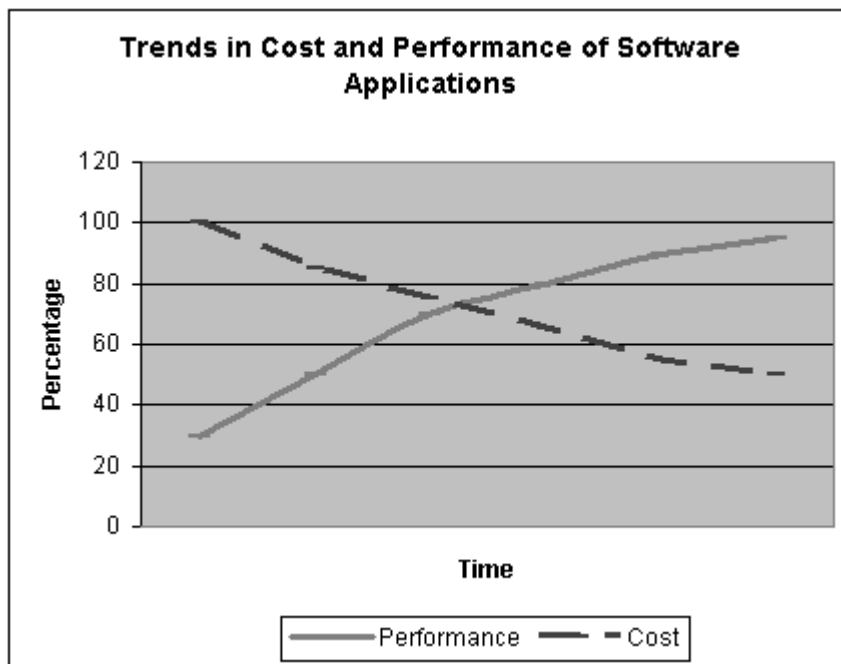


Figure : 4.4 Trends in Cost and Performance of Software Applications.

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http://www.thestar.com/NASApp/cs/ContentServer?pagename=thestar/Layout/Article_Type1&c=Article&cid=1035777395705&call_pageid=968350072197&col=969048863851

A brief history of the development of the 3DSmax software, which is predominantly used in architectural visualization, shows the frequent upgrades that have been introduced over the past few years. (See Figure: 4.5)

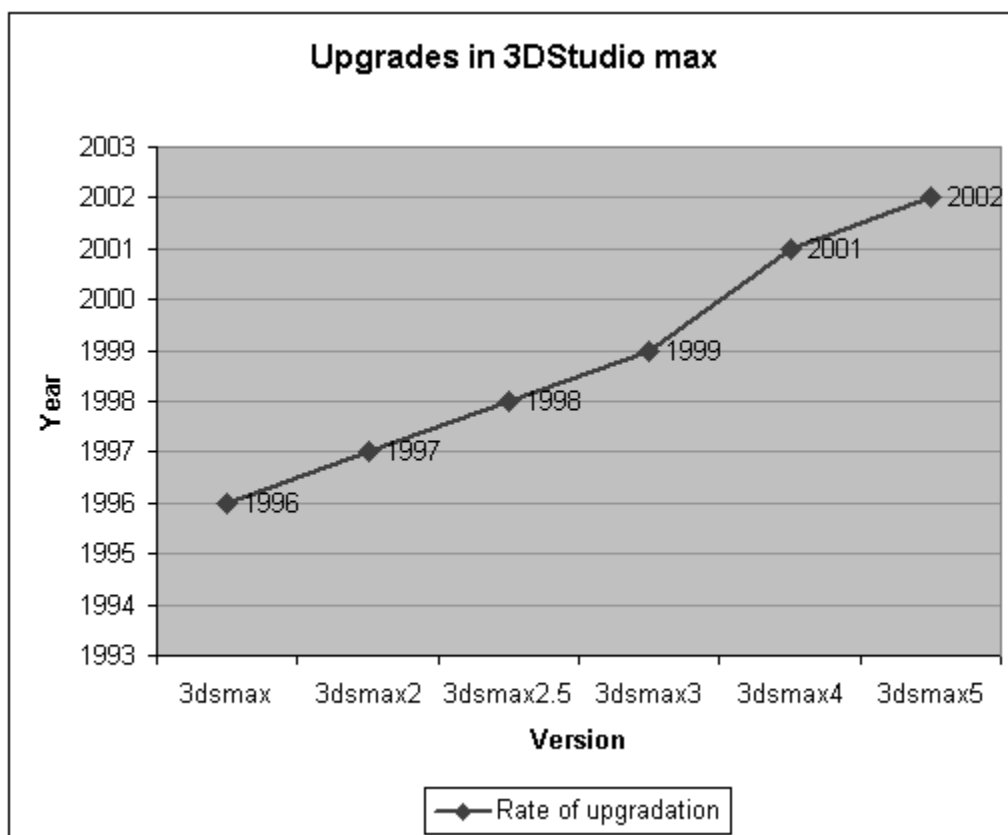


Figure 4.5: Retrospective of upgrades in 3DStudio max

With each up-grade, new features and enhancements are added which are the results of continuous research and user feedback. 3DSMax 2 was an augmentation to the user interface of 3DSMax version 1 and the interface has been continually improving in the later versions. In 1998 the 3DStudio Viz was released, which specifically catered to the architectural profession. 3DStudio Viz has all the features of Max which an architect

would use, but the high end special effects which are mostly used in the game and movie industries are eliminated. The software had added features for architects, aiding in easy adaptation in practice and a relatively low pricing which aided its success in the architectural market.

Release 3 showed significant improvements in the workflow and productivity, taking into consideration the studio workflow and collaboration. Organic free form modeling was greatly enhanced and the use of MAX Script provided more choices to the animation expert. 3DSmax 4 brought in more customization and enhanced rendering concepts like motion blur and depth of field which adds realism to the scene. The latest release Max 5 has added to this photorealism by adding enhanced global illumination with exposure control, photometric lights and new shaders. They can also now be exported to real-time 3D environments with Render-to-Texture, Normal Maps, and Light Maps.

Another interesting fact is that the cost of the software hasn't increased with each up-grade. 3DSMax is maintaining the same price tag of \$3,495 for a license and \$795 for each upgrade over the past five years. This shows the market growth of the software and its wide acceptance.

Following 3DSmax and Viz are the next level of simpler modeling tools. Form Z is highly popular in this category and is used significantly among the design schools in the United States. Figure 4.6 shows a tremendous increase in the number of schools adopting the Form Z "Joint Study Program" which is a clear indication of the increase in

awareness about 3D digital modeling and representation among present students of architecture.

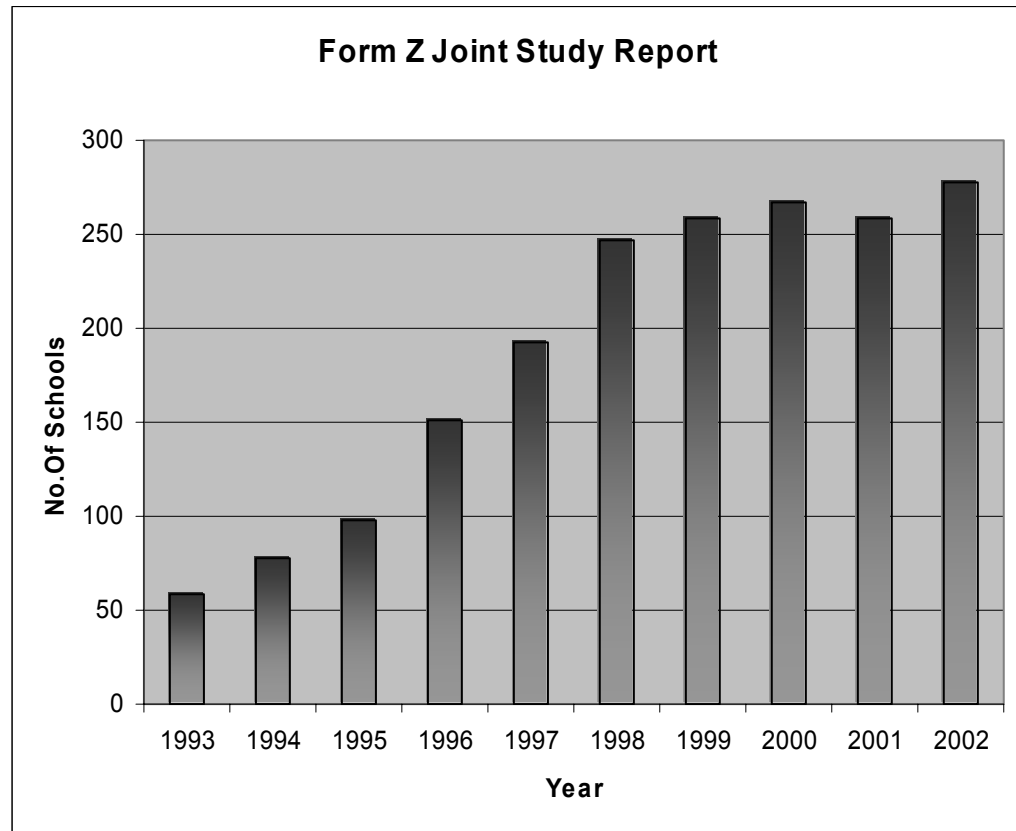


Figure 4.6: Form Z Joint Study Program Report
Source: Form Z Joint Study Program Report, 2001-02

SUMMARY

- The advent of the computer revolution introduced the use of Computer Aided Designing and Drafting techniques into architecture. (Circa 1970's)
CADD specialists were organized within the firm or outsourced according to the digital drafting needs of the firm. (Circa 1980's)

- Initially, architectural firms found it very challenging to adapt to digital means for their drafting purposes, some of the barriers being hardware/software affordability and non-availability of a computer skilled workforce.
- The growth of computer graphics led to many innovative techniques in digital art and these techniques were widely employed in the entertainment industry. (Circa 1980's)
- Architectural visualization derived inspiration from these techniques that were used in the entertainment industry. Complexities of these techniques impeded their immediate widespread use in architectural practice.
- Hardware and software industries are showing rapid progress with time. Processor speeds, graphics accelerators and memory are showing steady improvements.
- Newer techniques and user-friendly interfaces are incorporated with each software up-grade. Software applications are becoming less expensive owing to their wider acceptance and competition among vendors.

We have seen the growth and developments in the digital technology and their influence in architectural practice. In the next chapter we will look at the current scenario of digital architectural representations.

CHAPTER V

CURRENT CONTEXT

There is a huge diversity in the use of the digital medium among architectural firms. The size of the firm, location and the types of projects undertaken play a significant role in influencing the percentage of use in digital techniques. Though a detailed study of their usage is outside the scope of this research, this chapter discusses a few statistics which help us get an idea of the present scenario in architectural representation; the hardware and software used in architectural practices, the practical application of digital techniques and the research and developments that are currently in progress.

5.1 HARDWARE AND SOFTWARE UTILIZATION IN ARCHITECTURAL PRACTICE

Zweig White's publication on "The Information Technology & E-Business Survey 2002" serves as a major source of information in getting an idea of the current status of hardware and software applications setup in architectural firms. It is a natural trend that while the firms have progressed in their use of hardware resources with time, there is a wide disparity in levels of utilization of these digital tools.

The Zweig White survey for 2002²⁶ (See Figure 5.1) shows that the percentage of hardware expenses as a percentage of the total IT expenses is showing a decrease with time.

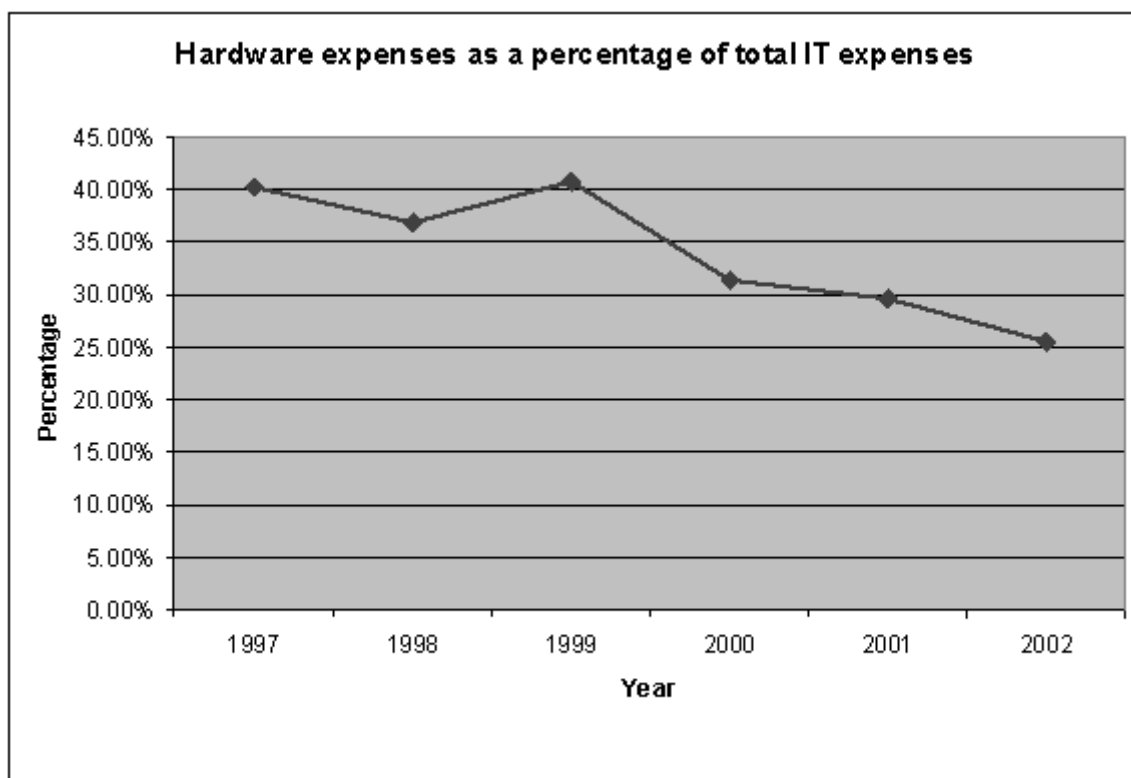


Figure 5.1: Hardware expenses as a percentage of total IT expenses
Source: Information technology & E-Business Survey, Zweig White, 2002

To get an idea of the present hardware infrastructure of the architectural firms let us look at the survey statistics of 2002. The operating systems used shows that the firms are predominantly windows based. (See Figure 5.2) Practically all firms (90%) use

²⁶ Information technology & E-Business Survey, Zweig White, 2002

Microsoft Windows 2000 on workstations. Another two thirds of firms (66%) use Microsoft Windows 98 and nearly the same number use Windows NT.

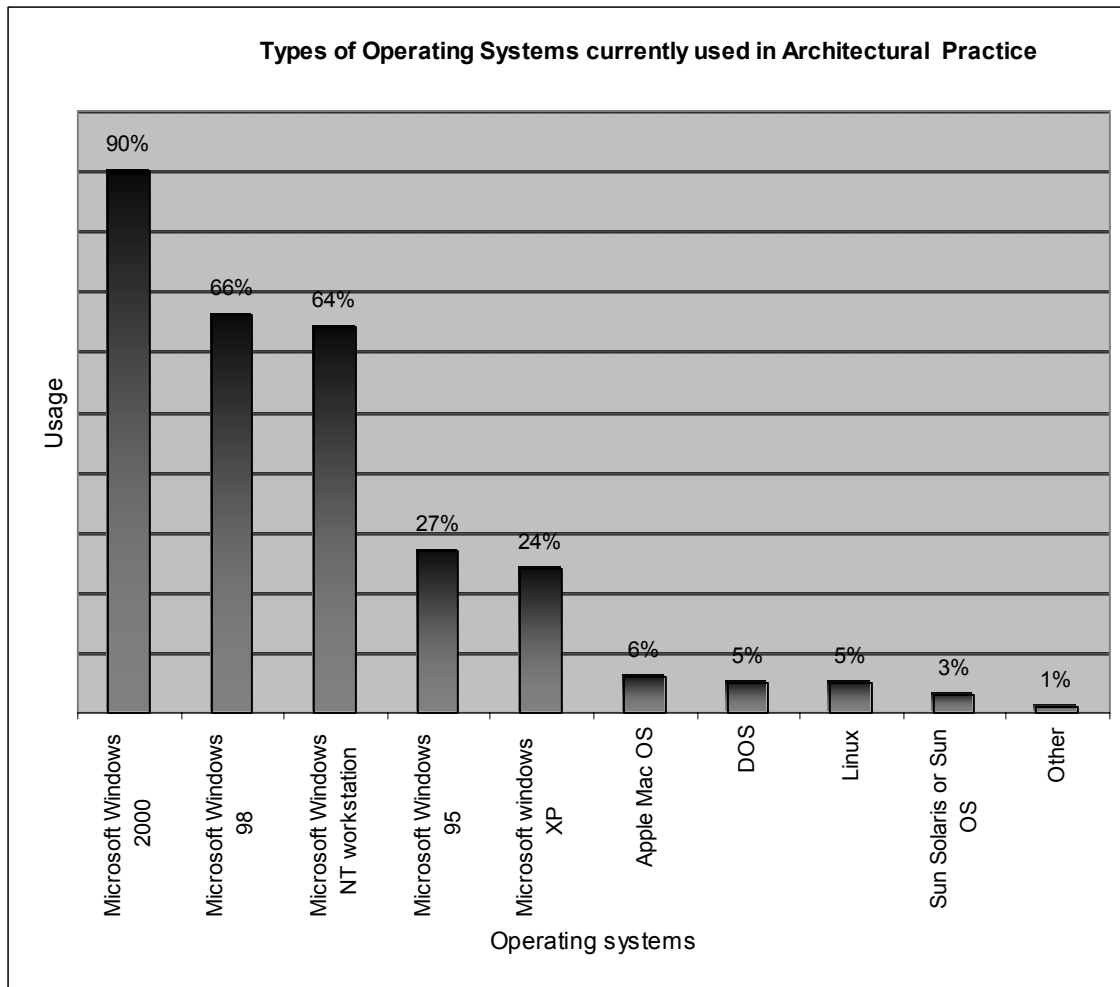


Figure 5.2: Types of operating systems currently used in Architectural Practice.
Source: Information technology & E-Business Survey, Zweig White, 2002

There is a very low percentage of Mac and Linux users (6%). Hence visualization softwares that are windows based have gained more popularity among architects. Though SGI's are capable of doing high-end graphics, they are rarely prevalent in architectural firms.

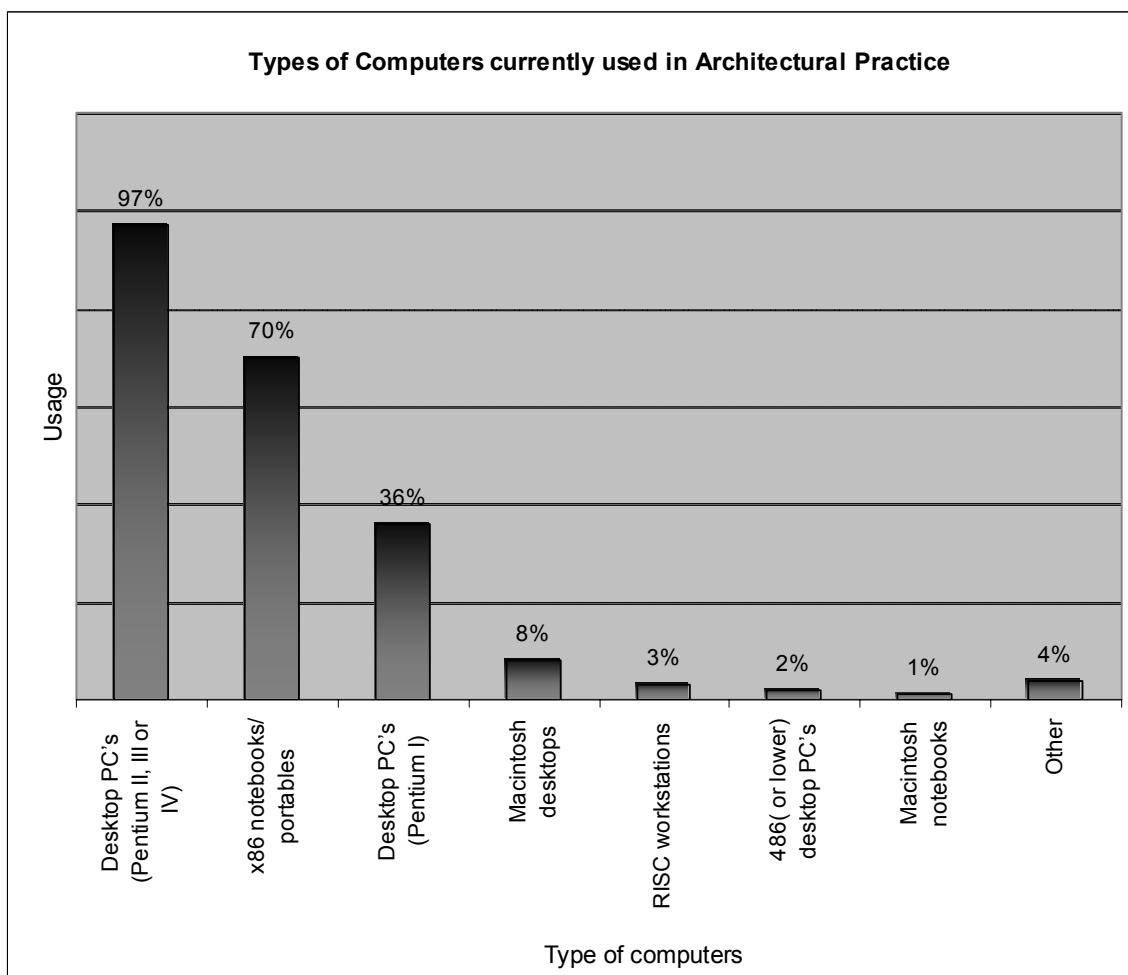


Figure 5.3: Types of computers currently used in Architectural Practice
 Source: Information technology & E-Business Survey, Zweig White, 2002

From Figure 5.3 we see that the use of notebook computers is on the increase (70%). The portability of the notebooks is being utilized for making client presentations and working and making changes to the design on the move or on job sites. The most commonly used machines are the Pentium II, III or IV.

A comparison is made between the slowest or the oldest computer that can be used by an employee in the firm and the specification for buying a new computer. (See Figures 5.4 – 5.7)

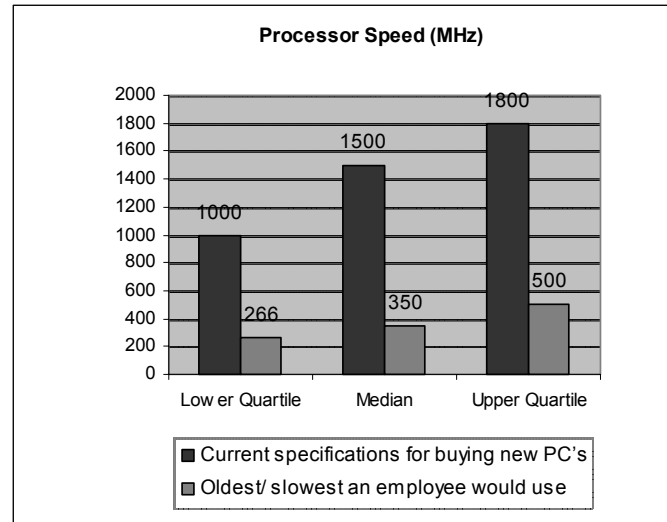


Figure 5.4: Comparison of processor speeds currently used in Architectural Practice
Source: Information technology & E-Business Survey, Zweig White, 2002

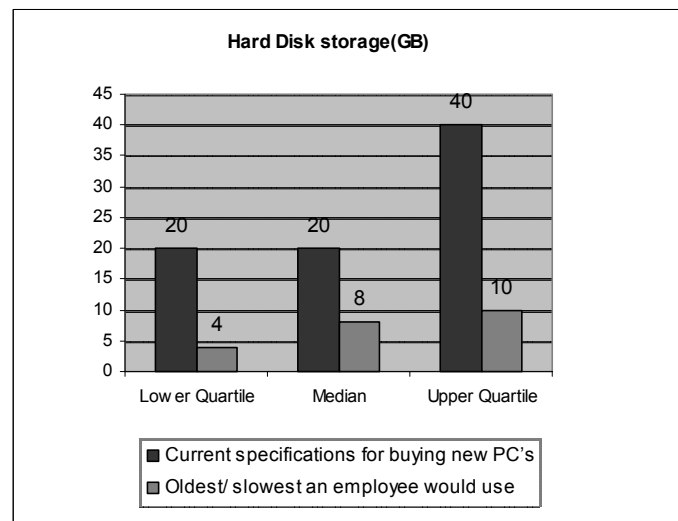


Figure 5.5: Comparison of Hard disk Storage currently used in Architectural Practice
Source: Information technology & E-Business Survey, Zweig White, 2002

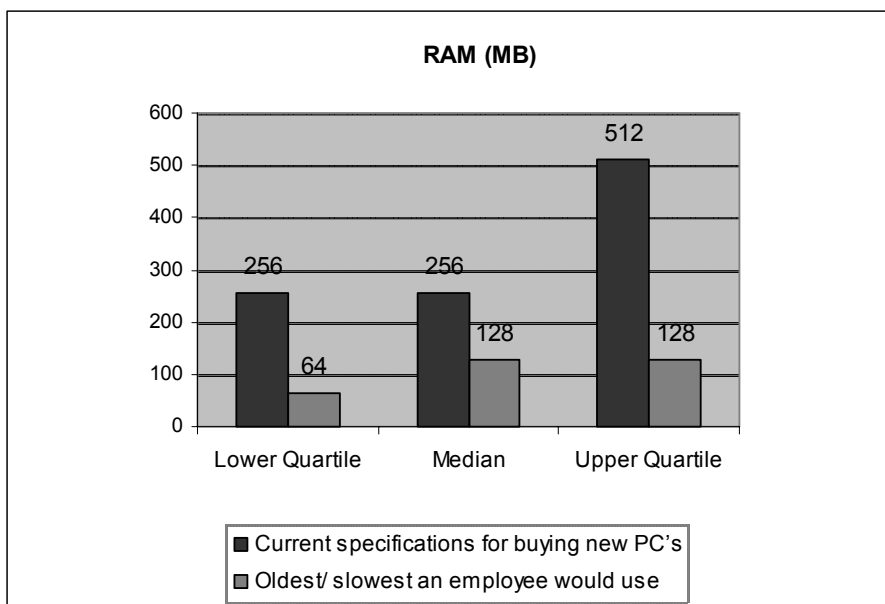


Figure 5.6: Comparison of RAM speeds currently used in Architectural Practice
 Source: Information technology & E-Business Survey, Zweig White, 2002

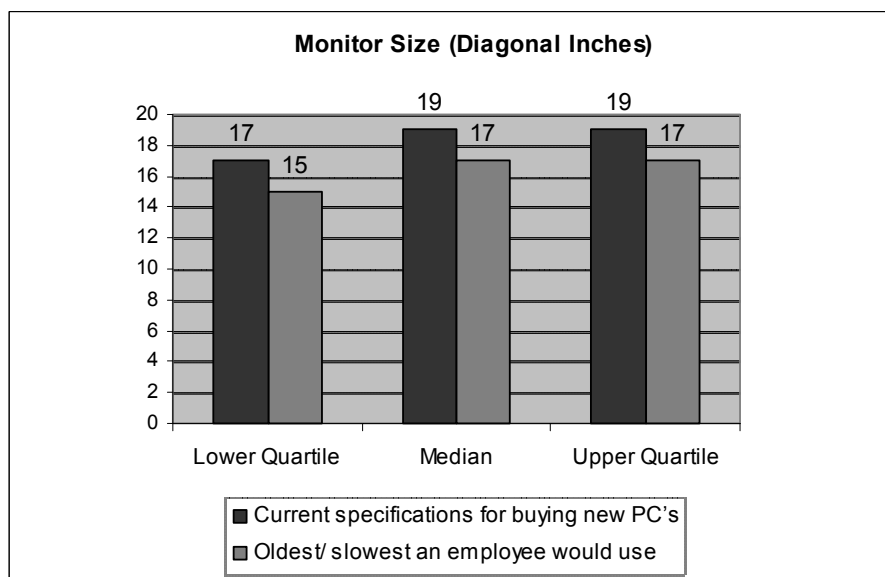


Figure 5.7: Comparison of Monitor sizes currently used in Architectural Practice
 Source: Information technology & E-Business Survey, Zweig White, 2002

When buying new PC's, the median specifications are a computer with a 1500 MHz processor speed, 20.0 gigabytes of hard disk storage, 256 megabytes of RAM, and a 19 inch monitor. At the other end of the spectrum the median specifications for the oldest or the slowest machine the firm would expect an employee to use is a computer with a 350 MHz processor speed, 8.0 gigabytes of hard disk storage, 128 megabytes of RAM, and a 17 inch monitor. Three to five years is the life expectancy of most PC's and servers. It was seen from the survey that the architectural firms typically replace machines every 36 months.²⁷

There is a marked difference in the specifications of processor speed, RAM and storage capacity of the oldest machine in the firm and the current specification for buying new ones, showing the steady advancements and improvements in infrastructure. Also, we see from Figures 5.4 – 5.7, that there is a huge variation between the upper and lower quartile of firms showing the diversity in the use of digital tools.

A survey on the most commonly used software in architectural practice was conducted at an architectural discussion forum at <https://pntel40.arch.kth.se> (See Figure 5.8) This survey, though not an exact indicator, gives an idea of the kind of software utilized most commonly in architectural firms.

²⁷ Information technology & E-Business Survey, Zweig White, 2002

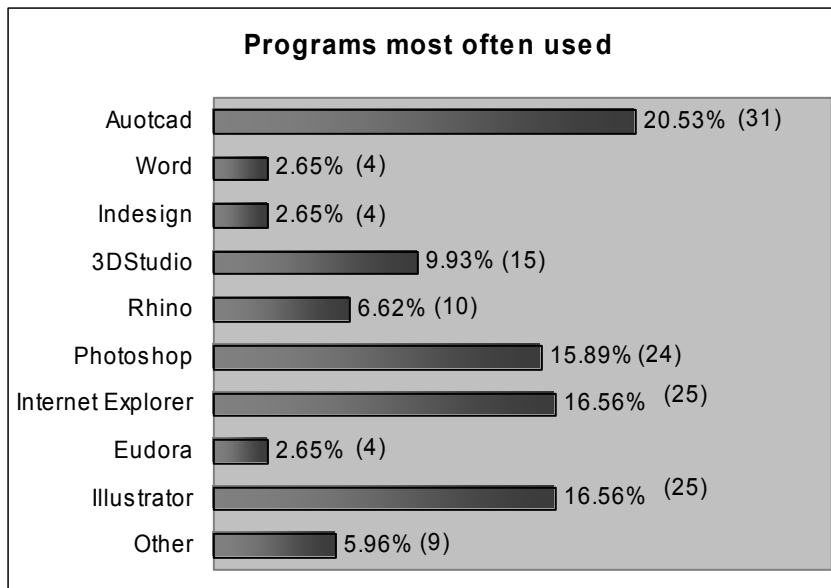


Figure 5.8: Programs used most often in architectural firms

Source : Survey retrieved on October 25 2002 from

<https://pnthel40.arch.kth.se/modules.php?name=Surveys&op=results&pollID=4&mode=&order=&thold=>

We see that AutoCAD is the most significant software application used in any architectural firm. Visualization software like 3Dstudio and Rhino are also used but to a lesser extent than the other applications.

A survey was hosted at www.DesignCommunity.com in an attempt to study the use of 3D CAD in the field of architecture. With promotional assistance from the American Institute of Architects, the survey attracted over 700 interested visitors with over 400 eligible respondents representing 3D CAD users in 32 countries. This survey

was available online from October through December of 1999. Most of the designers surveyed were relatively active 3D users.²⁸

It was found that early in design "simple" 3D models are preferred over "detailed" models, by a factor of 2 to 1²⁹. (See Figure 5.9)

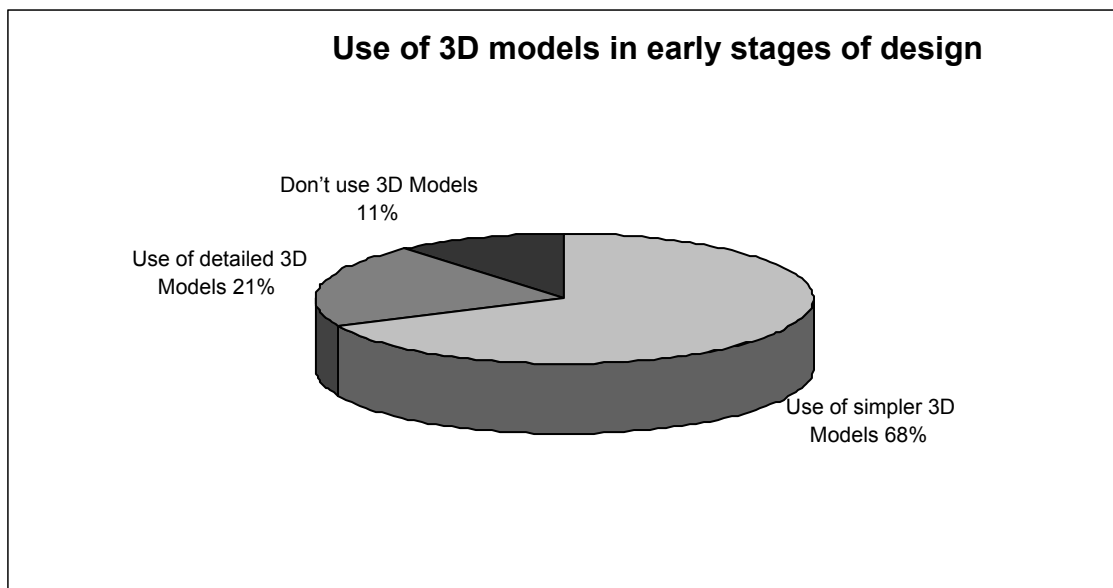


Figure 5.9: Use of 3D models in early stages of design
Source: Green CAD and 3D Design Survey, Retrieved November 15, 2002 from http://www.architectureweek.com/2000/0621/tools_2-2.html

However, detailed modeling is more popular later in the design process, when more than 42% use detailed models for their presentations. The kinds of representation depend on the type of project and the representation needs. The Figure 5.10 shows the frequency of use of the different levels of CAD assisted 3D presentations.

²⁸ Thomas Conlon, Green CAD and 3D Design Survey, Retrieved November 15, 2002 from http://www.architectureweek.com/2000/0621/tools_2-2.html

²⁹ Thomas Conlon, *ibid.*

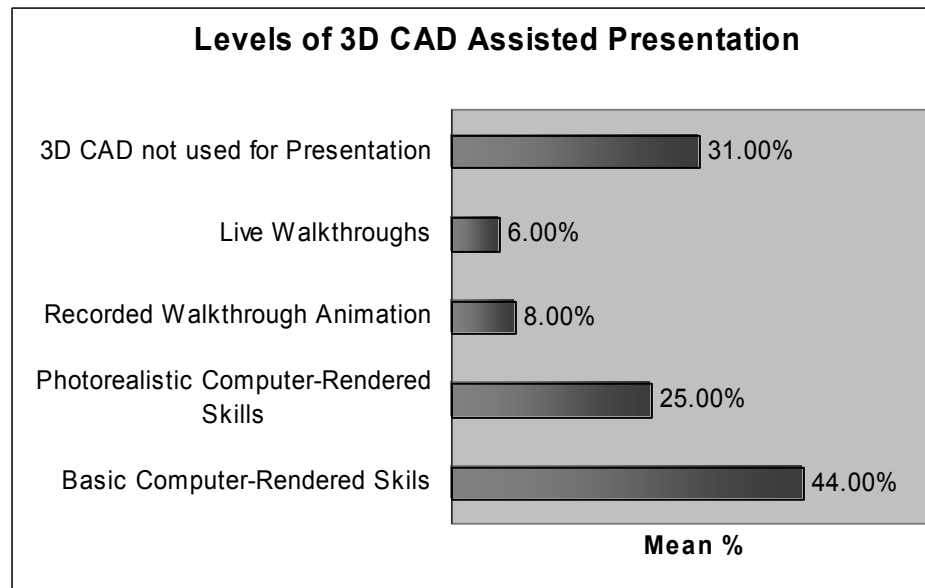


Figure 5.10: Levels of 3D CAD Assisted Presentation in Architectural Practice
 Source: Green CAD and 3D Design Survey, Retrieved November 15,2002 from
http://www.architectureweek.com/2000/0621/tools_2-2.html

Presently many architectural CAD software developers are concentrating their development efforts towards parametric modeling solutions. They have made major strides in creating an integrated CAD model which uses a common relational database whereby live sections and elevations can be directly output from the 3D model and any changes made in the design will be reflected in all the output drawings and specification tables.

A recent survey on the CADD environments currently used in architectural practice shows that AutoCAD is still dominating the architectural CAD market and the

other parametric modeling software are showing a progress in their usage.³⁰ (See Figure 5.11)

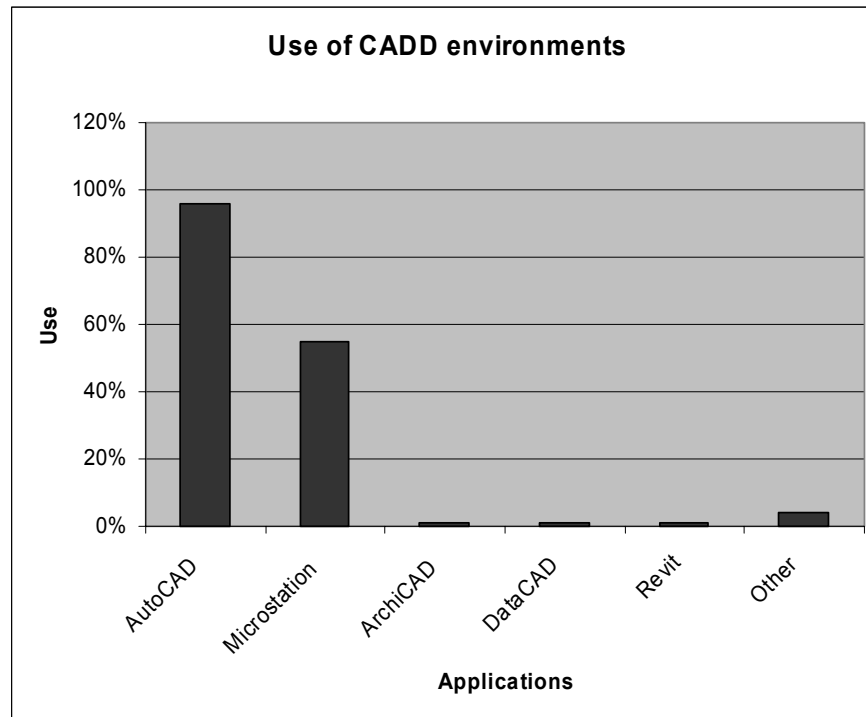


Figure 5.11: Use of CADD environments in Architectural Practice
Source: Information technology & E-Business Survey, Zweig White, 2002

A poll on the website www.cgarchitect.com on the kind of renderer preferred by the visualization architects shows that 3DSMax was the preference for more than half the voters followed by Lightscape which was preferred by around 1/3 rd of the voters. (See Figure 5.12)

³⁰ Information technology & E-Business Survey, Zweig White, 2002

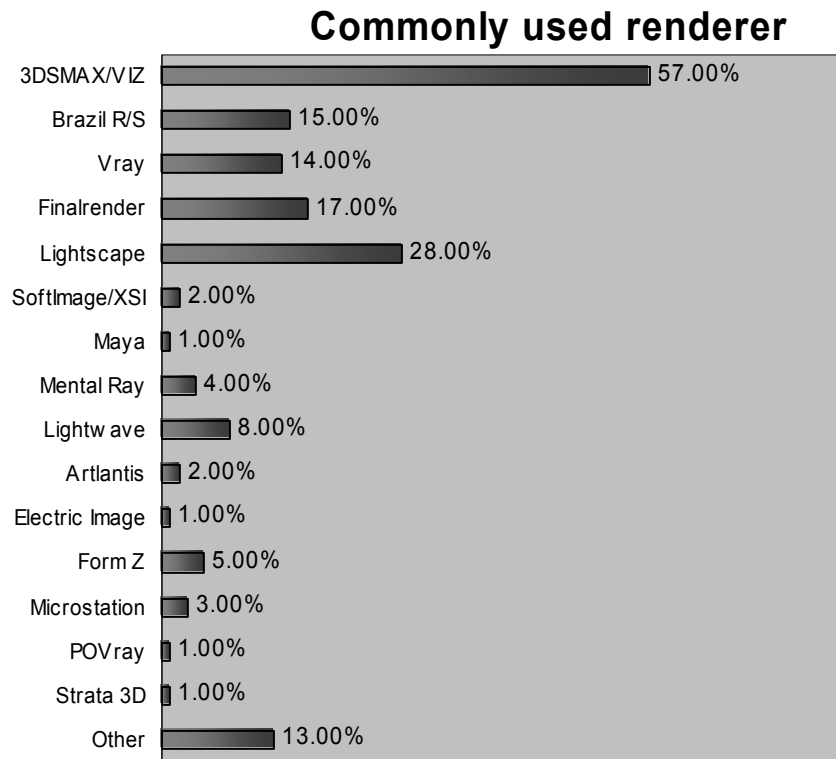


Figure 5.12: Commonly used renderer

Source: Retrieved November 15,2002 from <http://www.cgarchitect.com/cgi-bin/ultimatebb.cgi?ubb=forum;f=3>

The biggest challenges facing the IT industry at present were studied by Zweig White. The IT managers responses show that their main concern was standards followed by training issues, compatibility, upgrades and performance. (See Figure 5.13)

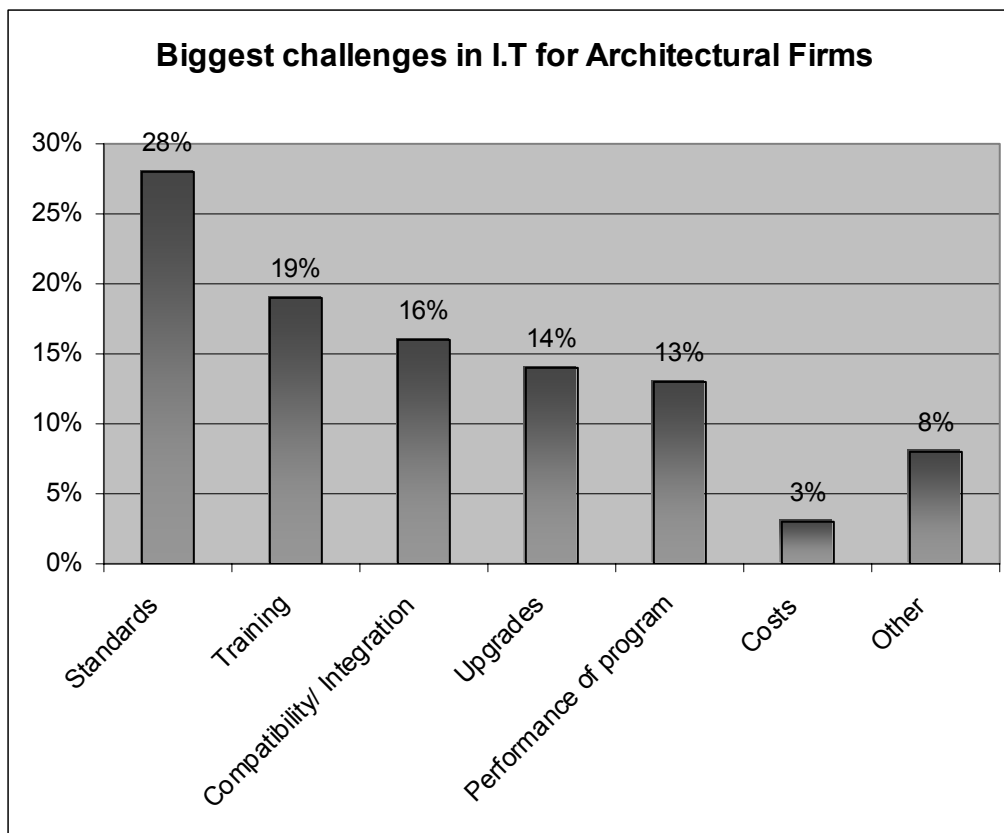


Figure 5.13: Biggest challenges of Information Technology in Architectural Practice
Source: Information technology & E-Business Survey, Zweig White, 2002

Additionally the Zweig White surveyed the architectural firms on their attitude towards software upgrades. It was seen that not many architectural firms upgrade their software with every new release. The survey showed that 53% of the firms often skip upgrades while 35% buy most of the upgrades.³¹

³¹ Information technology & E-Business Survey, Zweig White, 2002

5.2 VISUALIZATION TECHNIQUES – CURRENT PRACTICES

There is a growing awareness about the use of the digital medium among the young and exploratory architects. To keep up their competitive edge in the industry almost all firms have currently adapted digital means for two-dimensional drafting. After 2D CAD has become ubiquitous in architectural practice, the emphasis is currently shifting to 3D modeling and rendering practices. This section is aimed to give an idea of the possibilities and potentials of digital representation techniques presently in use at a few architectural visualization firms and their advantages over manual methods.

Digital representation serves as an excellent tool for the communication of design ideas to the client and to the team of other professionals collaborating in the design. The significance and efficiency of these digital tools are being evaluated in many architectural practices in comparison to the traditional representation methods, which include the physical models and the artistic renderings. Instead of a static rendering and time consuming physical models, we can now generate photorealistic renderings and walk throughs to effectively communicate the design ideas. The speed and ease of editing tend to save time freeing the architect from the physical strain on using manual methods.

One can imagine what an ordeal it would have been for the construction of the Sydney Opera House (1957 -73), designed by John Utzon at a time when there were no digital visualization techniques available. Although, the architect described his ideas of the sculptural organic form through sketches and words, major problems were encountered with the curved shell roofs regarding structural engineering, construction and cost. Figure 5.14 shows Utzon's section drawings for the Sydney Opera House.

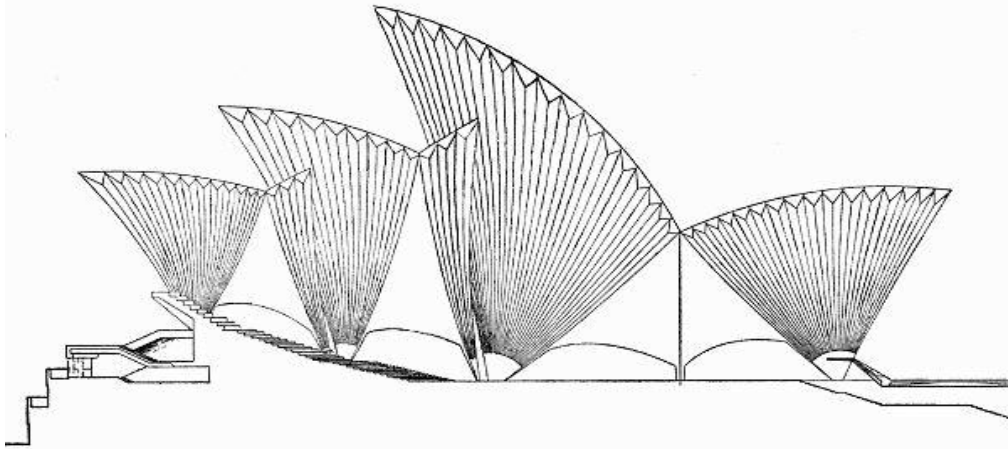


Figure 5.14 : Section through the Sydney Opera House
 Source: Sydney Opera House, Retrieved March 20, 2002 from
http://www.soh.nsw.gov.au/h/features/house_history/timeline/timeline_roofshells.html

The task of building the roof shells was estimated to occupy some 350,000 hours of Ove Arup's company time from mid 1957 to the end of 1965. Various concepts for the construction of the shells were tested and it was realized that the major problem was the shapes not fitting into a consistent pattern, making prefabrication costly and time consuming.³² Figures 5.15 and 5.16 show Utzon's solutions to solving the curves of the shell roof construction using wooden models and detailed drawings.

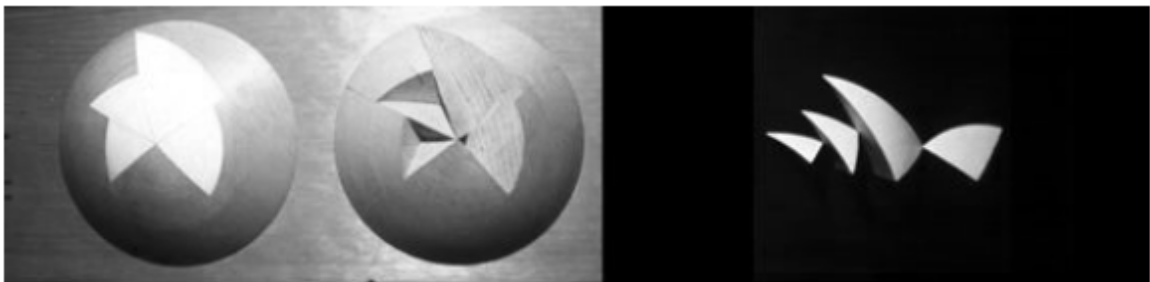


Figure 5.15: Spherical solution to the roof construction of Sydney Opera House
http://www.soh.nsw.gov.au/h/features/house_history/timeline/timeline_roofshells.html

³² http://www.soh.nsw.gov.au/h/features/house_history/timeline/timeline_roofshells.html

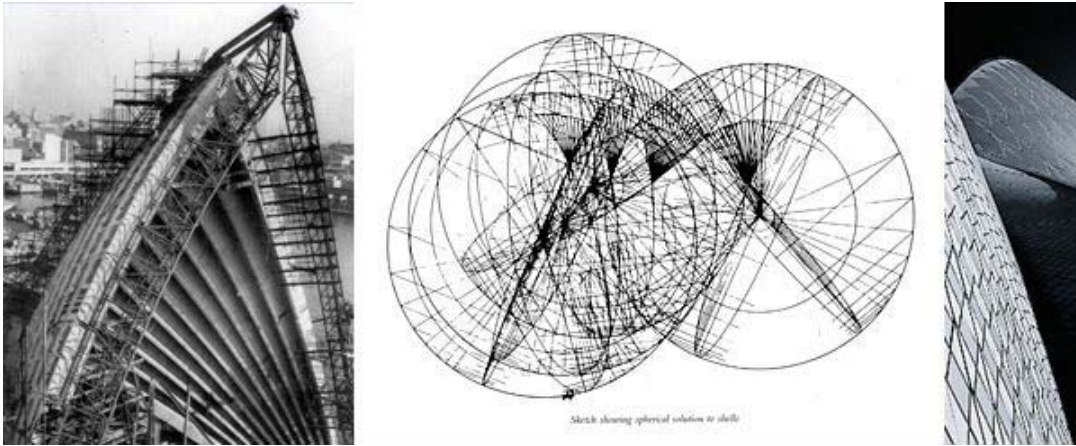


Figure 5.16: Shell Roof construction details of Sydney Opera House
http://www.soh.nsw.gov.au/h/features/house_history/timeline/timeline_roofshells.html

Comparing this to the culture and production of architecture today the digital techniques have progressed a long way in visualizing complex structures and forms. Designs can be communicated more effectively and the designer is able to visualize his structure, try out alternatives and solve design issues even before the building is built or even before the construction documents are made, thus saving huge amounts of time and resources.

Frank.O.Gehry's Experience Music Project (E.M.P), which was done in 1995-2000, is one such project that exhibits the appropriate utilization of digital techniques in communicating the design. Gehry derived inspiration for this design from a pile of trash he gleaned from an electric guitar shop near his office in Santa Monica. Defying the traditions of architecture and sculpture, EMP was very much about color tuned to evoke visceral responses.³³ Figure 5.17 and 5.18 shows Gehry's conceptual sketches and physical model studies for the EMP.

³³ The Building, Experience Music Project souvenir book

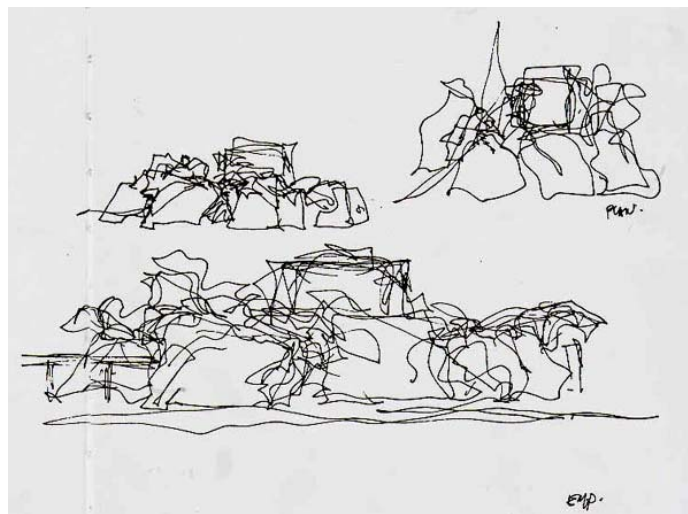


Figure 5.17 Frank Gehry's conceptual sketches for the EMP
Source: The Building, Experience Music Project souvenir book.

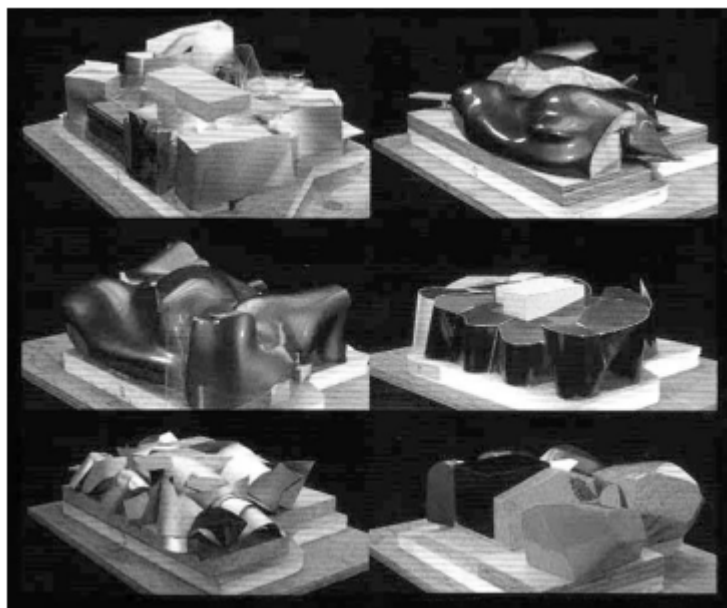


Figure 5.18: Physical study models for the EMP
Source: The Building, Experience Music Project souvenir book.

Around 100 physical models were made towards design studies for the EMP, but the building was ultimately born of advances in software.³⁴ CATIA, the software used in visualizing this complex sculptural form was originally developed for the aerospace industry. The need for precise shaping of the shell structures made Gehry utilize CATIA at the EMP.

Digital modeling was so integral to the design and construction of the project that the paper stage of construction documents was sidestepped. Computer aided manufacturing tools made it possible to cut the 21,000 eccentrically shaped metal shingles that formed the outer shell. These shells were cut by lasers guided by data generated directly from the surface modeling software, CATIA.³⁵

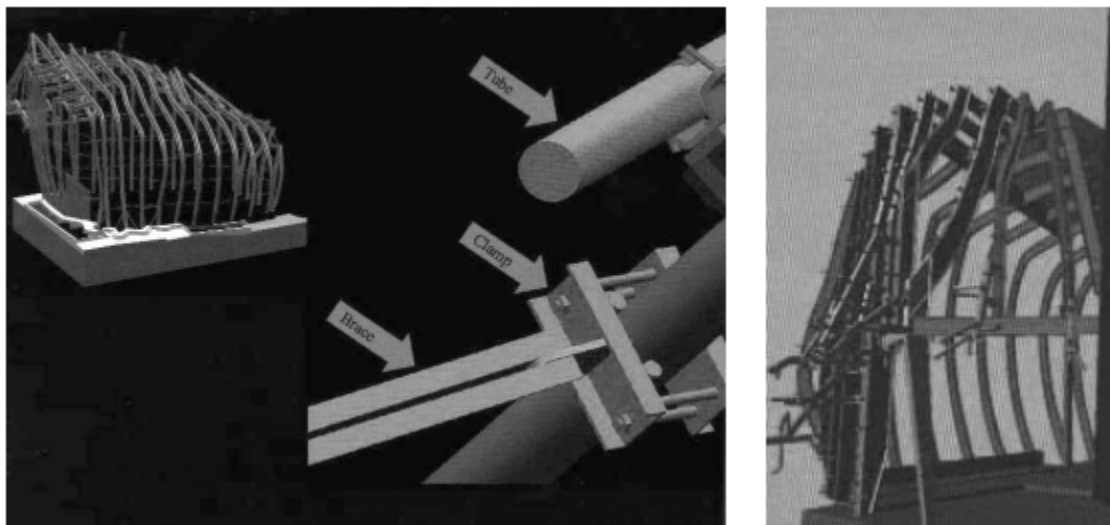


Figure 5.19: 3D model in CATIA

Source: The Building, Experience Music Project souvenir book.

³⁴ The Building, Experience Music Project souvenir book

³⁵ Jon Magnusson, 3-D software, the key to EMP's design, Retrieved March 15, 2002 from <http://www.djc.com/special/emp2000/software.html>

An architectural design competition was recently held for rebuilding at the World Trade Center site. The Max Protetch Gallery in New York City organized an exhibition featuring the design proposals from more than 60 architects from around the world. (See Figure 5.20) More than 50% of the entries were digital representations of conceptual models and renderings. This shows that many architectural firms, though not ubiquitously, have started adapting to digital means of 3D modeling and presentations.

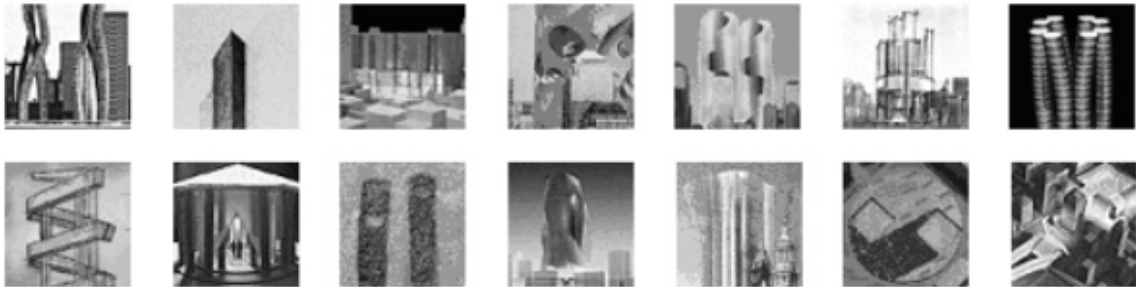


Figure 5.20: Competition entries for rebuilding at the World Trade Center
 Source: A New World Trade Center: Design Proposals, Retrieved March 1, 2002 from <http://www.construction.com/frameset.asp?p=http://www.archrecord.com/WTC/newWTC.ASP&pid=7.1>

Digital techniques aid in developing intuitive revolutionary concepts, opening up new vistas in design along with providing the designer an ability to consider all possible configurations in advance. This inevitable progression of technology is growing to such an extent that it is often not possible to represent or experience the world without the mediation of technology. New techniques are springing up frequently with the advancements in research, leading to more realistic and innovative methods of representation.

One of the main thrusts of the field of architectural visualization in the last few years has been directed towards achieving photorealistic effects. Photorealism is the art

of creating computer-generated scenes that appear so convincing that they are indistinguishable from photographs or film. The improvements in the graphics hardware have made it possible to achieve photo quality images. Graphics programmers and computer artists were the pioneers in the field striving relentlessly, putting in enormous time and effort to blur the distinction between the real and the rendered.

Using this technique, the architect can apply actual textures and lighting to evaluate and make design decisions instead of creating mockups and scaled models. Global illumination techniques are showing a steady progress with developments such as ray tracing and radiosity. Other advanced rendering techniques like photon mapping and image based rendering are also making great strides. These give an accurate depiction of real life lights and environments. Such techniques are now being offered with many recent versions of graphics packages making it easier to use for digital modelers and visualizers. The photo realistically rendered human figures, vehicles and landscape elements aid in accentuating the realistic look of the image when used in the right calibration of scale, light and color.

However, to achieve realism the visualizer puts in huge amounts of time and effort, which restricts the use of realistic renderings in most cases. The pristine nature of the renderings is another issue to be considered. Rarely do we come across such sights in real life. The lack of dust gives a “computerish” look to the images which are not preferred by many architects and clients.

Currently, the biggest divide between digital and traditional renderings is looseness, vagueness and abstraction. This makes architects develop a resistance against using digital techniques, which they feel gives a “cold” or “sterile” look. The architects feel that these renderings do not pose a revisable look to the client.

Non photo realistic renderings answer this issue through the creation of abstract artistic renderings. These non photorealistic rendering techniques have more artistic freedom for the expression of the idea and give the loose, schematic look that is required for certain cases. They are less time consuming due to the lack of exact details. Many software packages are currently developing filters and other techniques that aid non photorealistic renderings. The Figure 5.21 shows the use of non-photorealistic rendering techniques offered by the software Piranesi for conceptual design representation by Scott, Brownrigg and Turner.

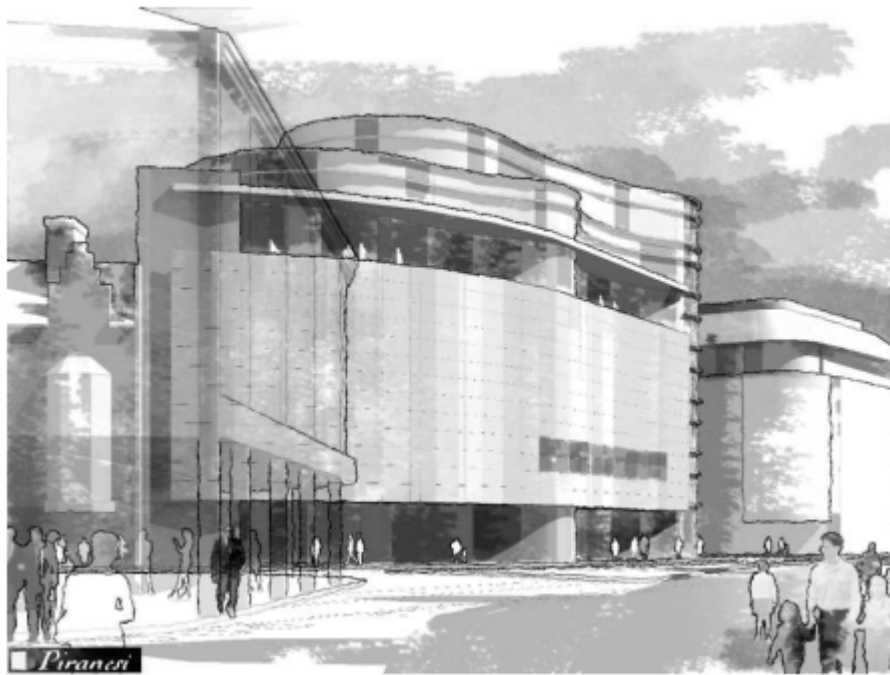


Figure 5.21 : Non photorealistic rendering, Scott, Brownrigg + Turner
 Source: Piranesi, Retrieved November 15, 2002 from
http://www.informatix.co.uk/piranesi/gallery_4.shtml

Until recently, the time necessary to model took up most of the portion in the process of digital representation. Now firms are budgeting more time for post production techniques. This is partly because the modeling software has improved over the years and the visualizer is getting more experienced at the digital modeling environment. Image editing software is sometimes being used to add human figures and landscape elements to make quicker and more effective two-dimensional outputs. Figure 5.22 shows a photomontage, where the digital model is juxtaposed on scanned photographs and the scale and lighting are tuned to depict the ambience of the setting.



Figure 5.22: Photo montage, Nethra Ram Mohan

Digital Hybrid techniques and mixed media presentations are coming to vogue making interesting compositions in representations. A few visualization architects blend the positive aspects of both traditional and digital mediums to create hybrid renderings. These renderings use computer generated images as a base and are juxtaposed with manual renderings means, making the process faster while giving the flexibility to try different camera positions. (See Figure 5.23) After rendering manually these are digitized again and edited in the digital environment if necessary. This technique utilizes the flexibility offered by the digital environment as well as helping to retain individuality in the rendering, giving it a more artistic look.



Figure 5.23 :Hybrid rendering. Ernest Burden III / O'Really Inc
 Source: Acme Digital, Retrieved November 20, 2002 from
<http://www.acmedigital.com/PA.html>

A variety of post-production software is being used to create interesting compositions for client presentations and more importantly for competition entries. Multimedia presentations give the added advantage of the fourth dimension, time (4D). Interactive and Non-interactive multimedia presentation with animated walkthroughs, drive throughs and fly throughs and audio tracks are added to the presentations making the designs more lucid and interesting.

Dallas FortWorth (DFW) International Airport, which is one of the pre-eminent airports in the world, utilized these digital techniques for the expression of design content to the clients and the collaborative team of specialists. (See Figure 5.24)



Figure 5.24: Dallas Fort worth International Airport – Terminal D Design
 Source : Dallas Fort worth International Airport, retrieved August 18 2002 from
http://www.dfwairport.com/cdp/terminal_d.htm

DFW 's comprehensive Capital Development Program, invested \$2.6 billion into the airport's infrastructure over a five-year time period with more than 51 architectural and engineering firms working on the design of the terminal and its parking garage.

The media lab at Corgan Associates was involved in making a digital model and multimedia presentation for the project in 2001. They had been involved since the first stages of schematic design of the terminal D project and have always had a fairly current digital model reflecting the alterations and modifications in design. The final visualization output was in the form of rendered images, animations and a VHS

multimedia output with audio track describing the facility to the client and the collaborative team. The videos served as an apt mode to combine all the information for presentations from the many consultants including the signage consultants, security, traffic engineers and concession consultants. The videos helped decision making throughout the team of these consultants, all of whom made a visual impact on the design.

Kyle Russell who worked on the visual representation says “Constantly, the design changes many times and is still changing, in fact it will change over the life of the building several times. But that is the strength of visualization; it gives a certain level of confidence about the direction of the design.”

The video aided in explaining lucidly the design of the facilities planned and the circulation patterns in the terminal. This visualization project, which had cost around \$550,000, comprises five 2 minute long sequences. It took a team of 2-5 persons about a month to create each sequence. They could split the project and work collaboratively making the work process more effective. Discreet 3DSMax and Combustion were used for this representation, which was very successful for communication of the design.

Architectural representation also makes use of a few interactive presentations in the form of Quick Time VR movies, but to a lesser extent than non-interactive videos, since the processor power is still not high enough to create high quality, detailed interactive presentations.

The academic scenario shows the inception of digital architectural visualization as a specialization of study in many architecture schools. This is one area where the

young and fresh graduates have an advantage over the experienced architects. They are preferred for their knowledge and skill in the latest technologies in the field.

Presently we see a wider awareness of the benefits of these visualization techniques among architectural firms. With the increase in complexities of design and more collaboration in projects these digital techniques are showing more potential for use in practice. These techniques are becoming more affordable, with the advancements in hardware and software applications. However, more complex techniques keep developing resulting in the present techniques becoming outdated very rapidly.

5.3 EMERGING TECHNOLOGIES IN ARCHITECTURAL VISUALIZATION

In the previous section we looked at the visualization techniques that are presently being applied in architectural firms and specialized visualization firms. There are many other visualization techniques emerging from the combination of image processing, computer graphics, and virtual reality which transcend the particular applications for which they might have been developed. These techniques are yet to be incorporated into the realm of architectural practice. Research centers in many institutions have taken up the task of conducting research on the emerging trends in visualization and computation and analyzing their use in architecture. In this section we will take a look at few of the research centers and their ongoing research projects which are aimed at exploring the shape of the electronic frontier.

Many researchers are currently working on making renderings more natural and realistic and reducing the “computer-y” look. Such an area of computer image generation is modeling and rendering of weathered materials, which is the focus of a research at the MIT funded by the National Science Foundation.³⁶ This research might be of good use for architectural visualization to make renderings more indistinguishable from the real, helping the client relate to the renderings in a better fashion.

The research center at MIT is also investigating on the visualization of light and sound in geometrically modeled settings in real time at interactive rates. Their research concerns development of simulation techniques to improve the accuracy of lighting and acoustic space evaluation, using theoretical and interactive techniques.

Virtual reality (VR), initially coined by Jaron Lanier(1989), is the area of research that for many years now, has shown many improvements and advancements. The use of VR in the year 2000 (See Figure: 5.25) shows that architecture and design evaluation is one among the top five uses of Virtual Reality. They are at present used primarily in research centers, however these researches would more often than not be incorporated into the commercially available applications for architecture in the future.

³⁶Department of Architecture, retrieved Nov 20, 2002 from http://architecture.mit.edu/research/bt/cg_mrwm.html

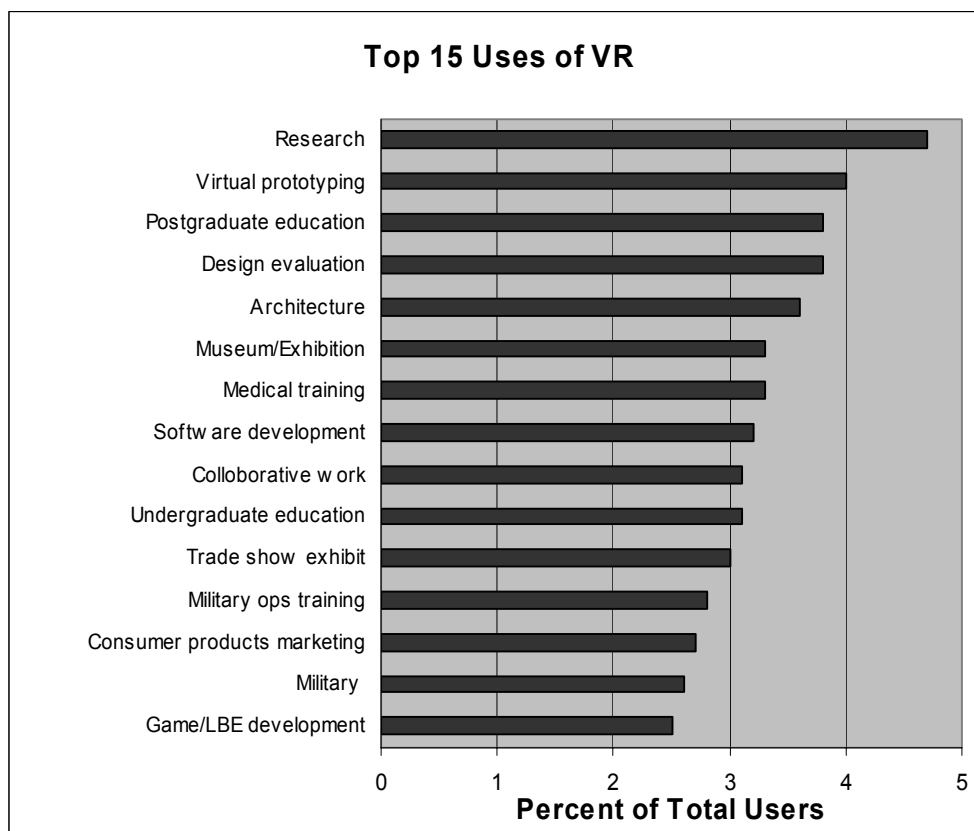


Figure 5.25: Top 15 uses of Virtual Reality

Source: Ben Delaney , What Became of Virtual Reality?

http://cgw.pennnet.com/Articles/Article_Display.cfm?Section=Archives&Subsection=Display&ARTICLE_ID=83573&KEYWORD=vr

Virtual Reality is applied to architecture both in the form of non immersive and immersive virtual environments. The term “non immersive” is also used for applications that are not fully immersive. This includes mouse-controlled navigation through a three-dimensional environment on a graphics monitor, stereo viewing from the monitor via stereo glasses, stereo projection systems, and others. Apple's QuickTime VR, for example, uses photographs for the modeling of three-dimensional worlds and provides

pseudo look-around and walk-through capabilities on a graphics monitor.³⁷ Though the boundaries between immersive and non immersive environments are becoming blurred all variations of VR would be of great importance for architectural practice in the future.

The Electronic Visualization Laboratory (EVL) at the University of Illinois at Chicago is a graduate research laboratory specializing in virtual reality and real-time interactive computer graphics. Since the 1970's, the Electronic Visualization Laboratory's research has focused upon the development of tools, techniques and hardware in support of real-time, highly interactive visualization. Their CAVE was the first virtual reality technology in the world to allow multiple users to immerse themselves fully in the same virtual environment at the same time.³⁸ This virtual environment is aiming at real time collaboration in design between persons from different physical locations.

In the Figure 5.26 three networked users at different locations meet in the same virtual world by using a BOOM device, a CAVE system, and a Head-Mounted Display, respectively. All users see the same virtual environment from their respective points of view. Each user is presented as a virtual human (avatar) to the other participants. The users can see each other, communicate with each other, and interact with the virtual world as a team.

³⁷ Virtual Reality: A Short Introduction, Retrieved November 20,2002 from <http://www-vr1.umich.edu/intro/>

³⁸Fakespace systems, retrieved November 20,2002 from <http://www.fakespacesystems.com/products1.shtml>

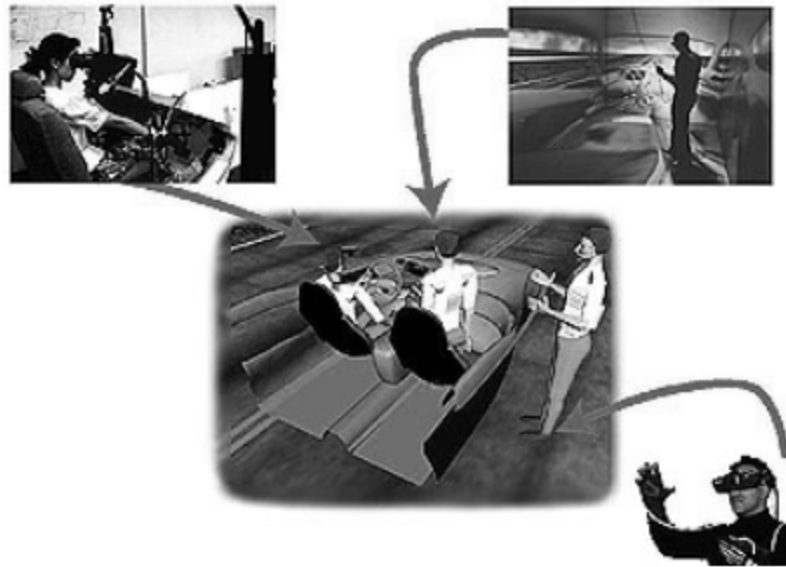


Figure 5.26: Collaborative Virtual Environments

Source: Reality: A Short Introduction, retrieved November 20,2002 from <http://www-vrl.umich.edu/intro/>

Demonstrating this network utilization in real world Tele- Immersion project is the Architectural Linked Immersive Virtual Environments (ALIVE)³⁹ project in the Electronic Visualization Laboratory. This project shows the practical implementation of this technology in the real world of practice.

Koolhaas/Office of Metropolitan Architecture won the Richard Driehaus Foundation International Award for the design of the New Campus Center in February 1998. Now the architects in Amsterdam and their clients in Chicago will be utilizing CAVE to CAVE Tele-Immersion technology between EVL and SARA (Academic Computing Services Amsterdam) to perform collaborative design reviews. ALIVE will

³⁹ Rem Koolhaas Uses the CAVE for Architectural Design, Retrieved November 20, 2002 from http://www.evl.uic.edu/activity/template_act_project.php3?indi=107

allow Dutch architect Rem Koolhaas to work on his design for the New Campus Center at the Illinois Institute of Technology in Chicago without leaving Holland.⁴⁰

EVL and SARA have developed a collaborative version of the SARANAV CAVE navigation tool, which will be used to load three-dimensional CAD models. This allows viewers to navigate through, create and re-play previously recorded animation paths. The avatars, audio conferencing and network instrumentation for monitoring bandwidth utilization, latency and jitter of network traffic during collaborative sessions are provided by the CAVERNsoft software application.

Currently there are a handful of CAVE's and virtual reality displays in research institutions. These systems require very large budgets and are not easily affordable. Many research groups are working on producing PC driven projection based VR displays. The Department of Media Study at the University at Buffalo is conducting research on low cost Virtual Reality systems. They have come up with a VR system that runs on two 700 MHz Pentium III CPU's, 256 MB of 100MHZ memory and a Matrox G450 AGP graphics card.⁴¹ (See Table 2) These ideas might be implemented into commercial hardware and software making it more affordable.

⁴⁰ Rem Koolhaas Uses the CAVE for Architectural Design, Retrieved November 20, 2002 from http://www.evl.uic.edu/activity/template_act_project.php3?indi=107

⁴¹ "A Low-Cost Projection Based Virtual Reality Display" Retrieved November 20, 2002 from http://www.evl.uic.edu/paper/template_pap_project.php3?indi=171

Table 2: Rough Cost for setting up a Low Cost VR system⁴²

Dual Processor PC	\$ 2,300
2 Infocus LP350 projectors	\$ 7,800
2 Extron Dist. amplifiers	\$ 480
Disney Black Screen	\$ 2,000
Screen Frame	\$ 1,000
2 Circularly Polarizing Filters	\$ 200
10 pairs of glasses	\$ 500
Spacepad	\$ 1,460
Wanda	\$ 2,500
Tracker PC	\$ 500
Sound PC	\$ 800
Amplifier and Speakers	\$ 1000
Miscellaneous	\$ 500
Total	\$ 21,040

Iowa State University's new C6 virtual reality theater is one among the few VR systems that support completely surrounding images and wireless interaction devices. The C6 is a 10X10X10 ft. room in which computer generated images are projected on all four walls, the ceiling, and the floor. C6 uses Silicon Graphics Onyx2 computers running on special software to create simulations, produce sounds, track feedback, and generate images. The high performance computer system can process more than 14 billion instructions every second. It can produce crisp, bright, and realistic images that respond to human interaction.⁴³

⁴² Siggraph 2003, Setting up a Low cost VR system, Department of Media Study , University at Buffalo

⁴³ Virtual Reality Application Center, Iowa State University, Retrieved November 15, 2002 from <http://www.vrac.iastate.edu>

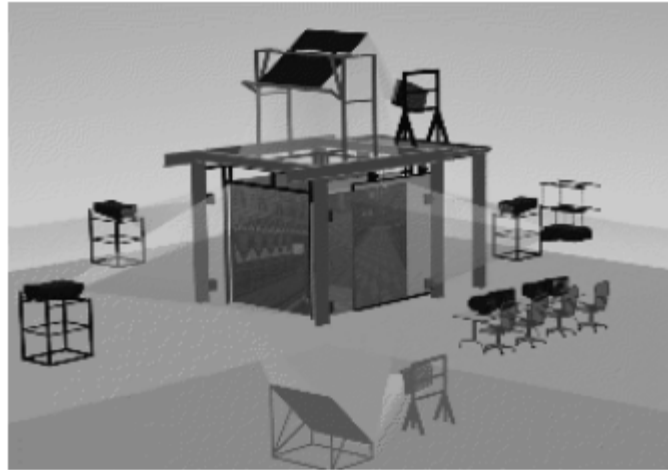


Figure 5.27: C6 lab

Source: Virtual Reality Application Center, Iowa State University, Retrieved November 15, 2002 from <http://www.vrac.iastate.edu/about/labs/c6/index.php>

VR environments are seldom used for extensive design exploration. The resources and effort required to apply VR techniques to everyday design are simply too high, impeding their implementation in architectural practice. Katsu Muramoto observes that the challenges include: historically high cost of purchasing and maintaining VR facilities, a scarcity of VR-enabled applications to which CAD users can easily adapt, the difficulty of programming new VR applications, and the resulting cloistering of such facilities within specialized research groups.⁴⁴

However, contesting these challenges, Virtual Reality is attracting a lot of application development vendors who are busy converting these techniques into the reality of practice. They strive to offer affordable solutions for the practicing architect to implement these technologies in the design and visualization of architectural environments. Table 2 shows a few examples of solutions offered by the leading vendors

⁴⁴Katsu Muramoto, George Otto, and Loukas Kalisperis, Diving Deeper into Designs, Retrieved November 15, 2002 from http://www.architectureweek.com/2002/1023/tools_1-2.html

in the virtual reality and large scale visualization areas. The growing number of these solutions and products shows the prospects of utilization of such technologies in the future.

Table 3: List of Virtual Reality Products and Vendors

Virtual Reality Technique	Product	Vendor
Cubic Immersive Environments	CAVE	Fakespace Systems Inc
	RAVE	Fakespace Systems Inc
	MoVE	Barco
	I -Space	Barco
	ICUBE	Barco
	TAN VR-Cube	Barco
Large Scale Visualization displays	WorkWall and Portico WorkWall	Fakespace Systems Inc
	CADWall	Barco
	BRCenter	Barco
	Concave Reality System	EON Reality
	VisionStation	Elumens
	GVR-X, PanoWall-X and FFP-X series	Panoram technologies
Virtual Projection Tables	ImmersaDesk	Fakespace Systems Inc
	Baron High Performance Projection Table	Barco
	Consul	Barco
	MICA	Barco
	VisionDome	Elumens
	Digital Imaging Table- 1,	Panoram technologies
	Team Display series	Panoram technologies

Another emerging technology that is showing significant potential in visualization of architectural spaces is the 3D printer. 3D printing is gaining popularity in many fields and these rapid prototyping techniques are also gaining their entry into the field of architecture. While conventional printers deposit a single layer of ink onto a sheet of paper, 3D systems create multiple layers of materials (resins, metals, plastics, cornstarch, and the like) one after another, until a complete, solid object has been formed. Users who connect a 3D printer to a computer running design software can create a physical representation of virtually anything imaginable.⁴⁵

Toybuilders.com (www.toybuilders.com), an online toymaker, is already using fabrication technology to create personalized action figures based on photos supplied by customers. Smith-Moritz expects downloadable toys to take off as soon as these printers become affordable for consumers.⁴⁶ This trend gives us a hint of what use these 3D printers can be put to, in the field of architectural design. In a few years these printers might become commonly available just like the photocopiers or 2D printers of today. Building models will be able to be printed out from any corner of the world for any particular design.

⁴⁵ John Edwards, Absolutely Fab, Retrieved February 15, 2003 from <http://www.cfoeurope.com/ecfo0701d.html>

⁴⁶ John Edwards , ibid

SUMMARY

- The present scenario in architectural offices shows Desktop PC's are predominantly used, followed by notebooks and other portable computers.
- A wide range of differences is seen in the hardware infrastructure of architectural practices surveyed among the architectural firms in the United States
- A marked difference is seen between the oldest computer in the firm and the newest one.
- Use of parametric modeling software is showing an increase
- Support facilities like online render farms are increasing.
- Digital visualization techniques are showing good potential for use in architectural practice.
- Complexities in design necessitate the application of high-end representation tools for communication of the design to the client and to the collaborative team of designers and specialists.
- Competition entries are showing increased use of digital renderings.
- Depending on the kind of visualization required, different techniques such as photorealistic, non-photorealistic, hybrid techniques, and multimedia presentations are used for representation of the design.
- Research centers are being quite progressive in exploring and creating innovative technologies, which can be used in architectural visualization.

Virtual Reality, collaborative environments and advanced lighting and rendering techniques are being explored at many research centers.

- Vendors are developing these latest technologies into commercial products for use in architectural practice. A number of new products that aid architectural visualization are becoming increasingly available in the market.

In this chapter we saw the current scenario of architectural representation. To study the extent of their utilization we will look into an architectural firm in detail in the forthcoming chapter.

CHAPTER VI

CASE STUDY OF AN ARCHITECTURAL FIRM

Currently we see that a few major architectural firms have started developing visualization facilities in-house, hiring specialists who meet their needs. There is a huge diversity in the use of the digital medium among architectural practices. The size of the firm, location and the types of project undertaken play a significant role in influencing the percentage of use of digital techniques.

HKS Inc is a progressive architectural firm which is open to new ideas and technologies. They have developed visualization facilities in-house to cater to the firm's visualization and representation needs. We will take a detailed look at the implementation of CADD technologies and digital representation techniques in HKS in this chapter.

HKS Inc, headquartered in Dallas with offices in Atlanta, Los Angeles, Mexico City, Orlando, Richmond, Salt Lake City, Tampa and alliances in the UK, provides professional services in architecture, planning, structural engineering, interior architecture and graphic design. Founded in 1939, the firm has executed design commissions for construction valued in excess of \$27 billion.⁴⁷

⁴⁷ HKS Inc, Retrieved January 20, 2003 from <http://www.hksinc.com>



Figure 6.1: Digital Architectural Representation rendered at HKS
Source: HKS Inc, Retrieved March 20, 2002 from <http://www.hksinc.com>

Since its inception, HKS's success has resulted in the firm growing to be one of the largest architectural and engineering firms in the nation with over 525 employees including 29 principals and projects in over 400 cities located in 44 states, the Districts of Columbia, and 19 foreign countries. HKS's business philosophy emphasizes performance in achievement of client goals. This philosophy has resulted in the consistent delivery of projects that are well designed technically, well executed and completed within budget and on schedule.⁴⁸

HKS was one of the pioneer's of applying CAD technology in architectural practice. It is interesting to study the history of CAD implementation in HKS and the

⁴⁸ HKS Inc, Retrieved January 20,2003 from <http://www.hksinc.com>

issues that these forward thinking architects considered before investing in computing technology.

CADD History:

HKS started working with CAD in 1983 with 8 employees. The working methodology of a project is such that each architectural project is lead by a managing partner, who maintains control and ensures continuity throughout the duration of the job. Design, construction documents, specifications and field administration are typically done by professionals in their respective departments with the support of specialists in code research, equipment, quality control or other disciplines as required by the project.

CADD implementation at HKS was based on the belief that CADD must be no more than a tool to expand the capabilities of professionals directly involved in the creation of architecture. As a corollary to this, involvement in CAD should in no way hamper the professional development of any employee. Adherence to these precepts had direct impact on the decision of HKS to become involved with CAD in 1983.⁴⁹

HKS established the fundamental criteria that a viable CADD system must be (1) easy to learn; (2) CADD skills once acquired must be easily maintained; and (3) being CADD “trained” would in no appreciable way dilute the primary educational goals of young architects, to develop as architects, not computer operators. Also a system must have the power to perform essentially all graphic and as appropriate, analytic tasks required in the architecture profession.⁵⁰

⁴⁹ Alfred. M. Kemper, *Pioneers of CAD in Architecture*, Harwood K Smith and Partners.

⁵⁰ Alfred. M. Kemper, *Pioneers of CAD in Architecture*, Harwood K Smith and Partners.

Prior to 1983 the evaluation of HKS was that no system on the market met the criteria established above. Continued monitoring of CADD systems led to the decision to purchase CalComp equipment in August of 1983. Two CAD management staff were organized and HKS started with four IGS 500 workstations which fundamentally appeared easy and natural to learn and use. The software was totally menu driven and supported by a screen devoted to alphanumeric prompting. The picture processor at each workstation allowed real time panning and zooming through the use of a joystick.⁵¹

It was approximately ten years later in 1993 that all construction documents were done in CAD. The advent of the personal computer and CAD software based on these PC's aided in the uniform immersion of CAD throughout the office. Soon thereafter additional support technicians were hired . Currently, HKS has 13 full time IT staff members including 2 database programmers.

In 1997 HKS extended its services and established the visualization lab in its headquarters at Dallas to meet the digital 3D visualization needs of the firm. Since its inception the visualization studio has grown and advanced dramatically. HKS Visualization studio is a multi-media production studio experienced in the production of three- dimensional computer modeling, animation, video production and website design. These visualization tools serve as high quality marketing tools for HKS clients. Using concept drawings, the visualization studio can evolve a project through studies of three-

⁵¹ Alfred. M. Kemper, *ibid.*

dimensional models, lighting, textures, and presentation renderings. The studio can further develop designs into sun angle studies, walk throughs and exciting animations.⁵²

Seven full time visualization experts who have a background in architecture or related fields are devoted to meeting the visualization and representation needs of the firm. In the design phase 3D representation is applied for trying alternatives and experimenting with forms and colors. (See Figure: 6.2) The multimedia presentations are used more for competition entries, marketing and final presentations.

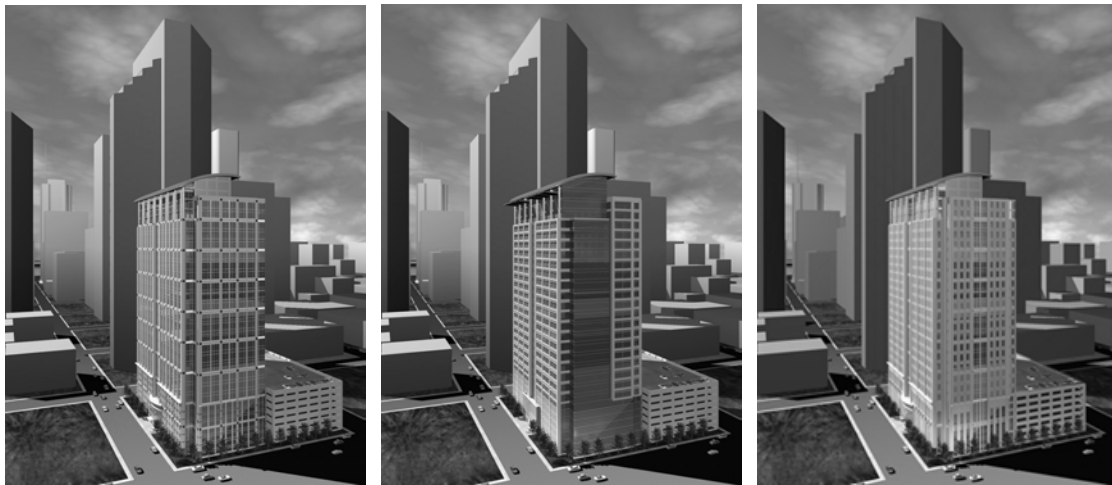


Figure 6.2: Digital models to try alternatives for an Office Complex at Houston
Image courtesy HKS Inc.

Currently there are about 900 active projects in the directory of the firm out of which 50 projects are utilizing the services of the visualization studio. A few visualization projects are also outsourced depending on the workload at the visualization studio. Approximately 80% of visualization work is done in-house and the rest 20% is outsourced to specialized visualization firms and freelancers.

⁵² HKS Inc, Retrieved January 20,2003 from <http://www.hksinc.com>

The use of visualization differs with the type and size of the projects. (See Figure: 6.3) Projects with a higher budget like sports, entertainment and health care projects show a higher use of digital visualization and representations. These disciplines budget a considerable amount of time and money for visualization purposes, which play a significant role in their competition entries.

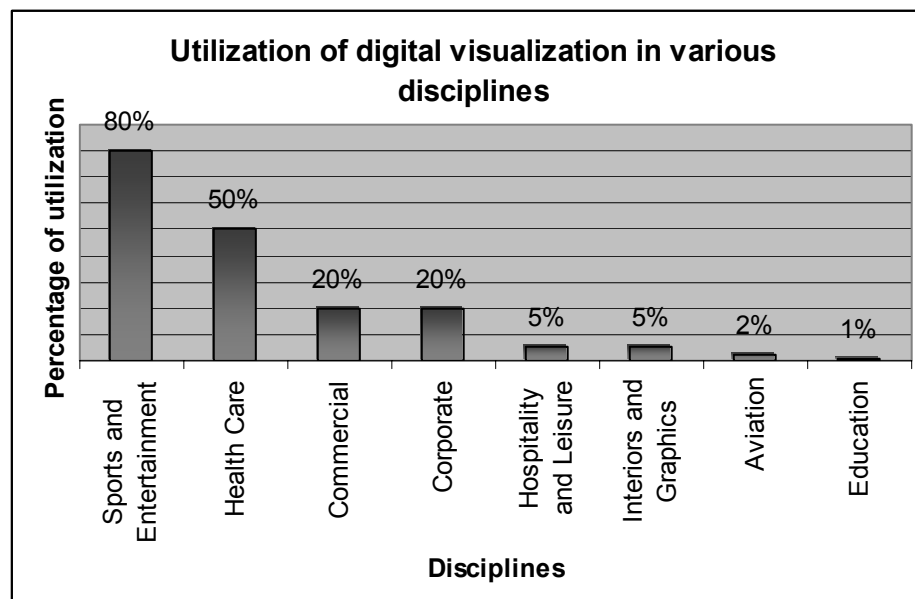


Figure 6.3: Utilization of digital visualization in various disciplines at HKS

A few disciplines like the hospitality and leisure depend more on manual renderings for representation of their designs. Though they use digital means for designs set in urban spaces, they prefer manual renderings over digital ones for designs that are set in natural landscapes. The digital techniques and libraries, although showing steady improvements, take enormous time and effort to replicate and render natural landscapes. The architects and clients are quite unhappy with the “computer-ish” look of the

surrounding natural environments, which they feel does not portray their passion for the design.

The visualization studio charges depending on the type of work and their fee is approximately \$100 per hour. The percentage in visualization expenses is split between staff, hardware and software. Staff is the highest taking up about 75%. Software occupies 17% while hardware takes up 6% of the total. (See Figure 6.4)

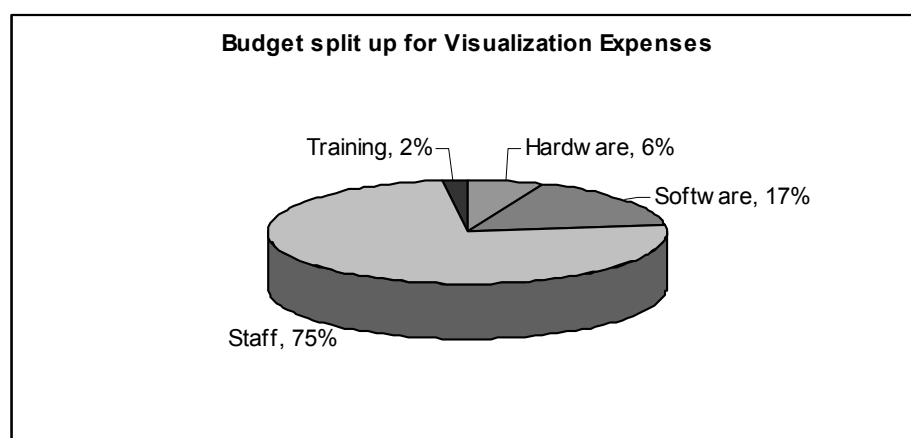


Figure 6.4: Budget split up for expenses at the HKS Visualization studio.

The most frequently used software at the visualization studio are Discreet 3DS Max, Adobe Photoshop, Macromedia Flash, Adobe Premiere, and DVDIt. 3DStudio Viz, Macromedia Dreamweaver, Director and Discreet Combustion are moderately used, while a few software namely AutoCAD, Adobe After Effects and Stitcher are used rarely in practice.

Depending on the advancement in hardware, the computers in the visualization studio are replaced when there is a significant change in their capabilities. They are

replaced about twice a year and these workstations are then used by other employees working in less intense applications.

Davis Chauviere, one of the Vice presidents and head of the IT department expresses:

“Our most unconventional ideas come from outside of the AEC environment. We look to other fields such as advertisement, graphic arts, movie industry, the entertainment and gaming fields.”

When asked about the improvements in the visualization studio five years from now he says “The biggest changes will be a much tighter integration of visualization with the design process along with real-time exploration rather than rendered animations.”

Taama Forasiepi, one of the Vice presidents and Director of the Visualization Studio expresses:

“Architectural visualization is fast approaching the entertainment industry. Our clients are requiring animations be integrated into full movie productions to sell their buildings to the public and investors. Conference rooms will be set up for immersion presentations so the clients can explore the designs interactively. Websites will be used more and more as a delivery tool for these animations, environments, and other projects data.”

SUMMARY

- HKS Inc is a progressive firm open to new ideas and technologies. It has a visualization studio in-house to meet the visualization and representation needs of the firm.
- They started using computers for CADD in 1983 and within a span of around ten years all construction documents in the firm were done in the digital environment.
- CADD implementation in HKS was aimed at aiding the architect with his tasks and not overpowering his responsibility as an architect.
- The visualization studio is meeting most of the visualization and representation needs of the firm.
- The extent of digital visualization used varies with the disciplines in the firm. Projects with higher budgets and competition entries show more utilization of digital techniques than the other projects.
- The visualizers look at the entertainment industry for inspiration and hope to integrate higher-end, movie like animations and interactive immersion facilities in a few years from now.

We have seen the utilization of digital techniques for architectural visualization at HKS Inc. The architectural firms which do not have these facilities in-house outsource their visualization projects to specialized visualization firms or freelancers when necessary.

Let us take a brief look at the growth and progress of a few digital visualization firms in the next chapter.

CHAPTER VII

SURVEY OF ARCHITECTURAL VISUALIZATION FIRMS

Outsourcing architectural renderings has been in vogue in architectural practice since the late nineteenth century. With the emergence of digital techniques for rendering these “ghosts” or “renderers” slowly transformed to digital renderers and visualizers.

The application of 3D digital techniques in the field of architectural visualization emerged in the late 80’s but it was only practiced to a very small extent by in-house exploratory architects. During the next decade, the significance of digital visualization grew and by the late 90’s these newer technologies and infrastructure requirements led to the development of firms specializing in digital architectural visualization. Architectural firms which can not afford digital architectural visualization in-house rely heavily on outsourcing to specialized firms and freelancers for their illustration and presentation needs. In this chapter we will take a glimpse of the present business models and practice strategies of these visualization firms.

A survey was conducted at the MSU School of Architecture, Digital Research & Imaging Lab (DRIL) among a few prominent visualization firms to get an idea of the current visualization demands in the field, their present infrastructure and skill composition. This survey was conducted through November 2002 and it received a response rate of 25%. The World Wide Web made it possible to conduct this survey at a global level.

In general the survey revealed that the practitioners are progressive in their use of the state of the art computer tools for visualization and have the capability to handle bigger projects and tighter deadlines. This is possible mainly due to the broader skill set available through the collaboration of experts from various related fields. There is a wide variation in the kind of visualization firms depending on the services they offer and their location. The firm sizes range from 1 – 15 persons with their age ranging from 1-6 years in practice.

A majority of employees working in these firms have an architectural background facilitating a good understanding of the subject they are visualizing. There are quite a few other backgrounds in the team who include computer programmers, design artists, illustrators, technical draftsmen, structural engineers, lighting experts and marketing executives. (See Figure 7.1)

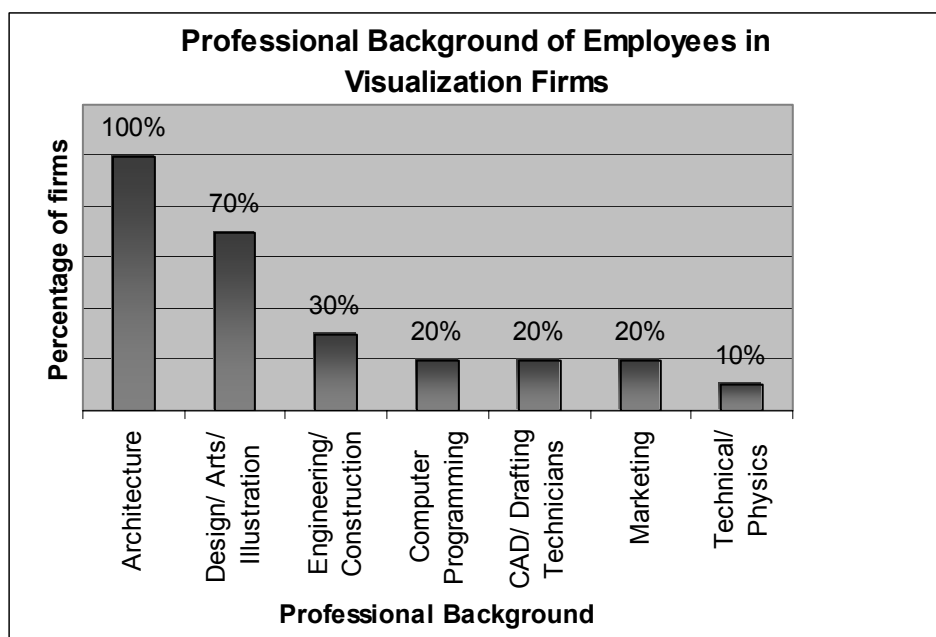


Figure 7.1: Professional Background of Employees in Visualization Firms

Depending on the number of employees and the diverse background of the employees an efficient pipeline of work is planned and executed. A few initial sketches are developed and then the design goes through modeling, texturing, lighting, animation, rendering and post-production stages. In smaller firms all these phases of the project are handled by a single person. In larger firms with more employees, it is more of a collaborative effort with work divided and accomplished according to their specialized

team members skills. The division of work allows modeling and rendering to be kept separate speeding up the process by working simultaneously.

Except for a few firms who use proprietary applications, most of the firms use commercially available software application for visualization purposes. Though these cannot be concluded to be absolute percentages because of the smaller sample surveyed, Discreet 3DStudio Max and Autodesk's AutoCAD are the software which are used most extensively. Rhino, 3D Viz, and Lightscape are few other prominent software in use. (See Figure 7.2)

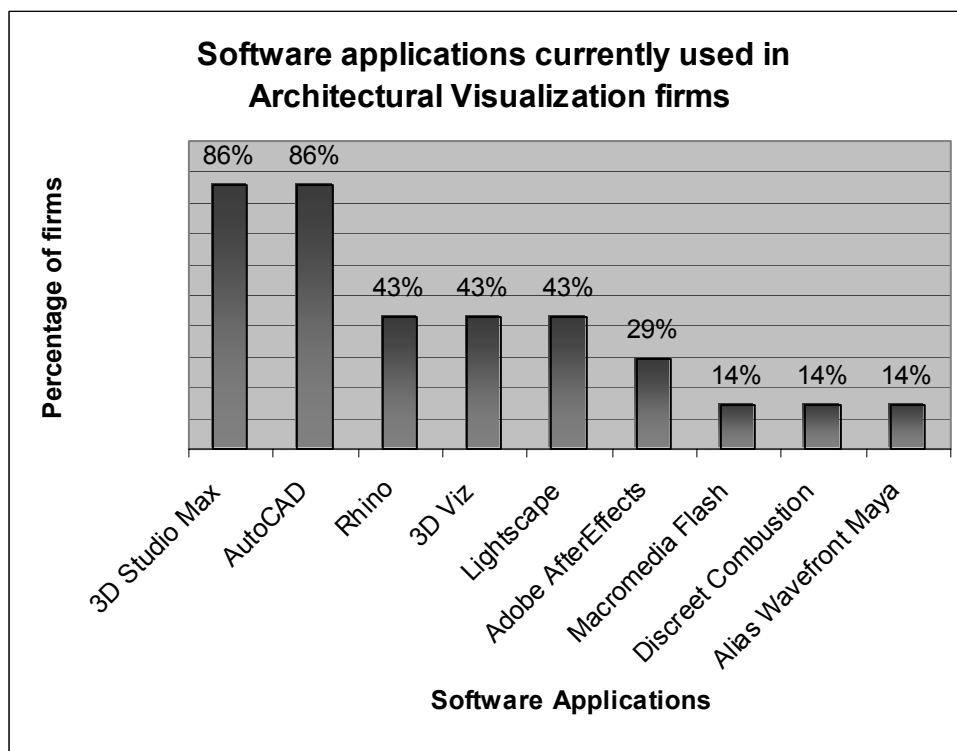


Figure 7.2: Software applications currently used in Architectural Visualization firms

Presently, with the development of the internet the world has shrunk to a single entity where information is transferred from one side of the globe to another in a fraction of a second. The physical place where the visualization project is done is no longer a crucial factor. The visualization firms which are remote do not have the advantage of collaboration in design however the internet provides easy and rapid access to any communication and discussion between the designer and the visualiser. Around 70% of the firms surveyed have internet based clients and 40 % of the firms have clients from the area where they are located. Most of the files are transferred to and from the firm through Email or FedEx services. The improvements in the internet connection speeds are aiding faster data transfer between remote clients and the architect. Around 40% of the firms also use FTP sites to transfer files and outputs.

Visualization firms have better facilities and infrastructure and a wide variety of skills than many other architectural firms which have in-house visualization. They are quite progressive in their hardware setup to meet the heavy requirement for faster processors and huge memories for visualization. Most of the firms are PC based and they use a PIII or P4 workstation loaded with a GB or more of RAM. NVIDIA, GeForce and Wildcat are being the common graphic cards used. A few firms have set up their own render-farms to meet their rendering needs.

The degree of detailing and the kind of output usually dictates the allotment of the number of hours and the cost for the project. The charges for visualization also depend upon the geographic location and the quality and detailing of work. 30% of the firms surveyed charge between 15- 50 U.S.D and 40% of the firms had higher charges ranging

from 50 - 100 U.S.D or more (See Figure 7.3). The need for quick turnovers and less expensive renderings has led to many firms springing up in the developing countries which are capable of doing quicker visualization for lesser pay mainly because of their location and workforce.

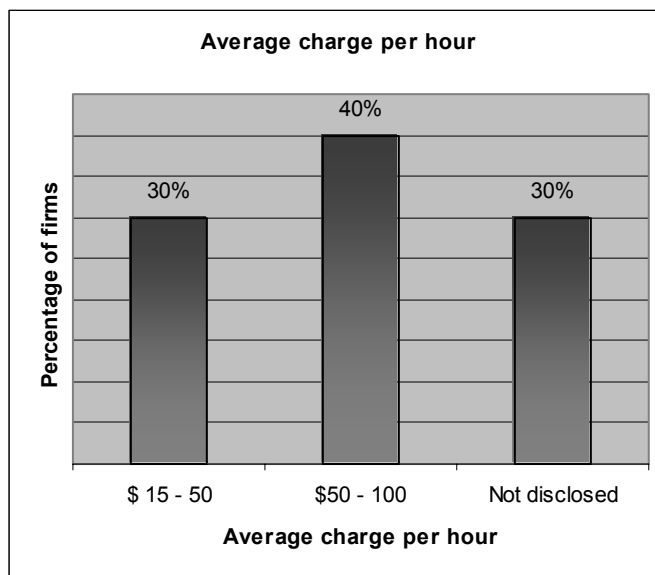


Figure 7.3: Average charges for Digital Visualization per hour

These visualization firms aspire to stay in the forefront of technology and are usually composed of individuals who aim to be the best in the field. They take into their team people who have both artistic skills and an architectural background. However, their requirement for imagination and artistic talents are higher than their emphasis for architectural backgrounds. (See Figure 7.4)

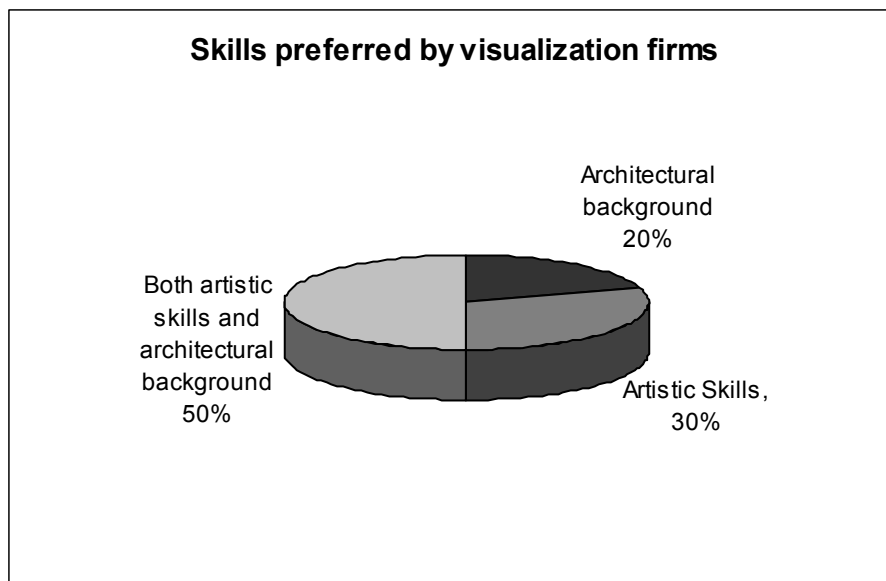


Figure 7.4: Skills preferred by Visualization firms

Quality lighting and realism are their aspirations in the given reality of deadlines and infrastructure. A few firms also excel in digital techniques like non photorealistic renderings and digital hybrids which includes a skillful combination of the digital medium with the traditional medium and multimedia presentations. For any visualization firm their portfolio is their main marketing asset. Though “the kid in the garage” style of freelancers is also progressing, 60% of the firms believe that sophistication of the office in terms of the image, website, etc helps develop a good clientele.

This has led to many visualization firms and freelancers for architecture throughout the world lending their services overseas to the major architectural firms. CGCrystal, an architectural visualization firm based in China has presently employs 320 persons and serves an international client base through the internet.

Architectural in-house visualization Vs Visualization firms

When we compare architectural in-house visualization services to the services of specialized visualization firms each one has its own advantages and limitations. Not many architectural firms can support the infrastructure, time and resources required for high-end visualization. However, in-house visualization helps better communication with the designers and the visualizer is more involved in the design process. The design being viewed in 3D digital models from early stages also helps in making design decisions apart from serving representation needs. However, good project management is extremely important. From a visualization specialist's stand point, it is much tougher to do visualization in-house since there are too many alterations in the design. Also, 3D digital representation comes as the last stage in the whole process, which makes it tougher on the visualizer to meet presentation deadlines.

In-house visualization also serves as a great marketing tool for an architectural firm. The firm would take pride in walking their clients into the 3D visualization studio which is one of the most technologically advanced departments in the firm, showing them pretty pictures and animations of their works.

Outsourcing digital representation helps in getting the project done much quicker , though for a higher cost. More often than not, the designer out-sources the project after the major design decisions are made and not many alterations are done after looking at the model. The visualization firms have expertise from many related fields and are more flexible equipping them to achieve quality results much more quickly. They tend to invest

on the time and resources to stay abreast with the technological advancements to a much higher degree than most architectural firms.

The recent trend shows that architectural firms are moving towards doing their 3D digital works in-house, but as technology advances and becomes more and more specialized there will probably be an increase in specialized visualization services.

According to Kyle Russell from Corgan associates, Dallas

“It is unrealistic to expect a person to be proficient in two different professions. Architecture is a profession unto itself, it took me 5 years to graduate with an architecture degree (professional) and that time barely scratched the surface of what the entire profession is about, it taught design thinking mostly. Well animation is a complete profession all to itself (if done properly) the same way with compositing, editing, modeling, camera tracking. All of these fields are complex in their own right and it is impossible for someone to be concerned with all the aspects of architecture and still be competent at all these professions. But it is the nature of the architect to try anyways, we all have that shortcoming.”

SUMMARY

- The firm sizes range from 1 – 15 persons with their age ranging from 1-6 years in practice.
- They are located in varied locations across the world and about 70% projects are done through the internet.

- The firms have employees from varied professional backgrounds including architecture, arts, engineering, construction, computer programming, CAD draftsmen, marketing and other technical fields like physics.
- These firms are progressive in their utilization of specialized hardware and software for visualization.
- The charges for projects show a wide range depending on the location of the firm and the kind of visualization work.
- Visualization firms located in developing countries are offering less expensive services and quick turnovers.

We see that digital visualization firms are evolving and progressing very rapidly as a specialization in architecture. They are capable of doing higher end visualization because of their skill base. However, to gain expertise in this field it takes significant amount of time and effort, which are discussed in the next chapter.

CHAPTER VIII

PERSONAL EXPERIENCE USING MAYA

The software applications that are developed for computer graphics are powerful programs with extraordinary capabilities. However, power always comes with a price. These software tools take a substantial amount of time and effort to learn and master. The learning curve associated with them is one among the several barriers for the digital visualization migration in architectural firms. This chapter describes my experience with learning a high end visualization tool which can be used for architectural visualization.

The concept of the learning curve was introduced to the aircraft industry in 1936 when T. P. Wright published an article in the February 1936 *Journal of the Aeronautical Science*. Wright described a basic theory for obtaining cost estimates based on repetitive production of airplane assemblies. Since then, learning curves (also known as progress functions) have been applied to all types of work from simple tasks to complex jobs like manufacturing a Space Shuttle⁵³.

⁵³ Learning Curve Calculator , retrieved January 20,2003 from www.jsc.nasa.gov/bu2/learn.html

A learning curve shows the relationship between the resources spent in performing a task and that spent when the tasks are performed over time. Its slope reflects how quickly a person or an organization improves with experience. For instance a factory worker might take an hour to wrap the first 50 articles and then about 50 minutes for the next 50 and around 45 minutes for the next 50 articles. (See Figure 8.1)

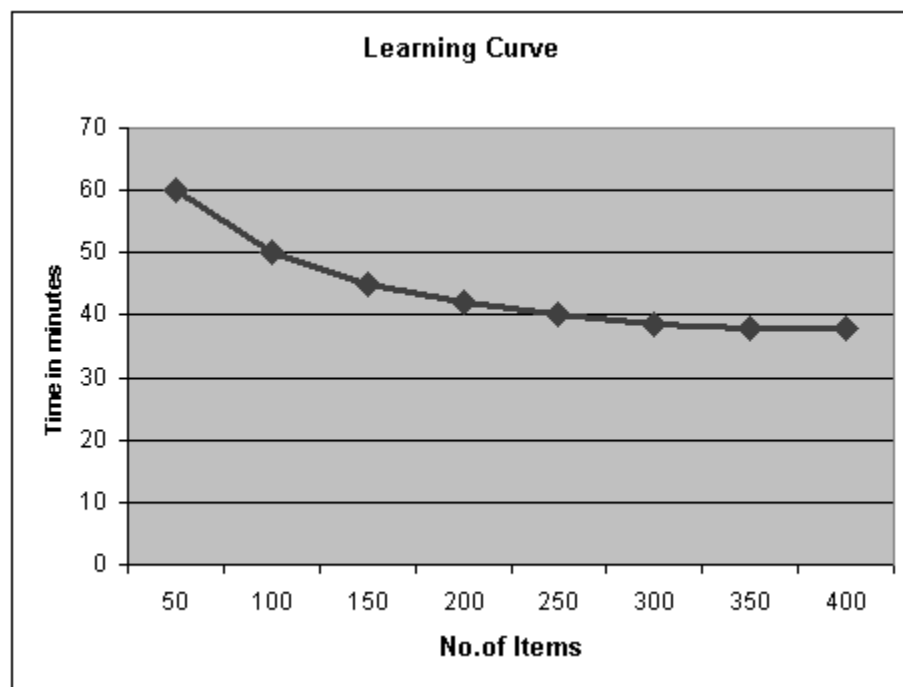


Figure 8.1: Example of Learning Curve

In the context of learning to use a software application it denotes the effort required to learn and master the application considering the man-hours spent and the cost. This can be compared to learning an art form like dance where learning the basic movements is arduous but once a person is proficient at the basic movements, it takes

lesser time to learn new and more complicated moves. The basic concepts in the software applications are similar, learning simpler software applications paves the way for learning new more complicated high-end ones.

I took up the design of a museum of modern art using Alias Wavefront Maya as a means of studying the latest advancement in the field of architectural visualization. The objective of the research was to explore a high end visualization software in terms of its 3D modeling features NURBS, Polygons and Subdivision surfaces and various rendering, texture mapping and presentation techniques. To explore these areas the design of a museum of modern art was chosen which allows for the play of challenging forms and composition. The scale of the project was quite large with the total built area of the museum complex being 18,000 square meters (SQ.M), with a 13,000 SQ.M gallery area and around 5,500 SQ.M of support area.

The building was designed as a piece of sculpture in itself. Organic spaces are fusing into one another making a graceful continuous flow of experiences for the user. Maya was chosen because it provided a flexible environment to work on organic forms. The digital techniques offered in maya aided in design and visualization of the interesting spaces formed by complex geometries. The different translation issues from other related software and compatibility issues with the different operating systems were considered before choosing Alias Wavefront Maya as the software for exploration.

Adopting new technology tools can be quite challenging, however, prior understanding of the basics of the art and craft of visualization are a great benefit to the engagement of new software applications. Prior to exploring Maya I had a basic

knowledge of modeling and rendering from my previous experiences in using manual methods of constructing and rendering perspectives and using the 3D digital visualization software applications like 3DStudio Max. My prior knowledge helped reduce the learning curve and grasp a more complex and powerful tool like Maya.

The initial conceptual sketches were generated using traditional hand drawings , maya was then utilized for developing the design .(See Figure:8.2) Many different alterations of the proportions were then explored in the digital environment.

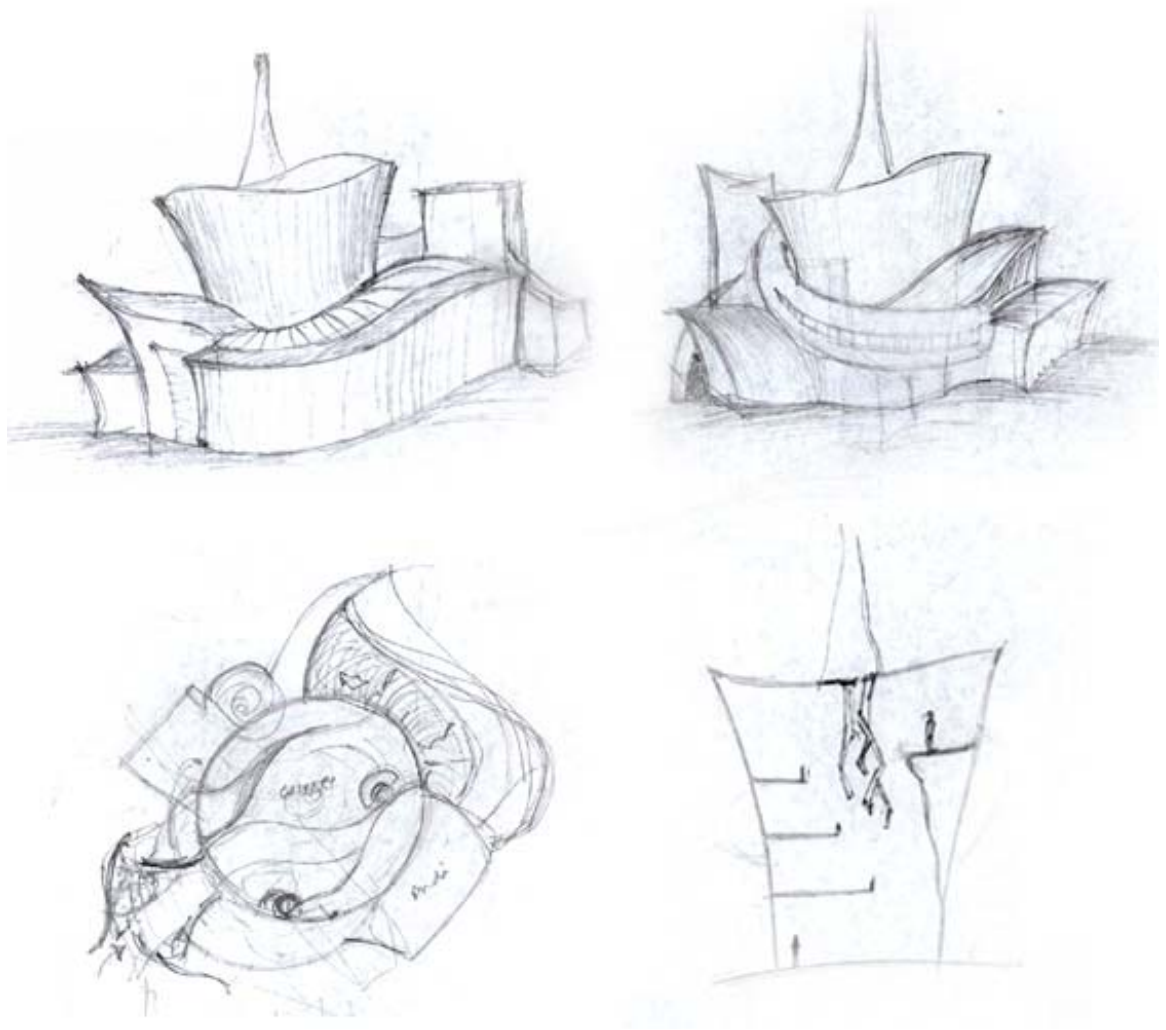


Figure 8.2: Initial sketches of the concept

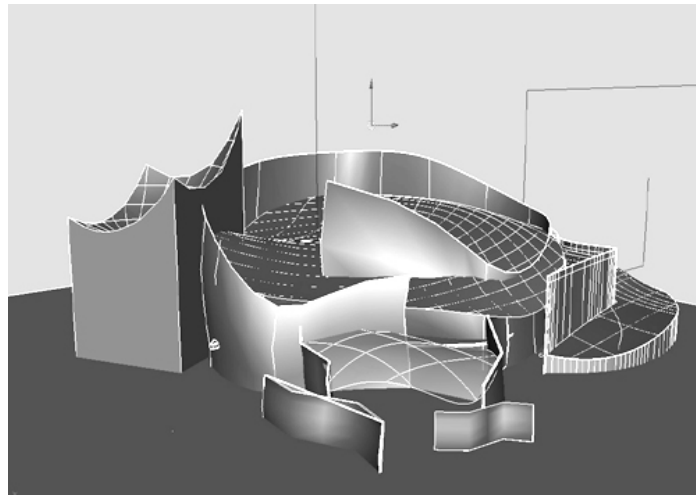


Figure 8.3: Initial modeling of form using Polygons

Learning the tool and designing simultaneously was very exacting, involving extra effort initially. Deciding on which technique of modeling and representation would best suit the design project required exploratory research and experimentation. After some exploration, modeling using NURBS surfaces proved to be a better tool for visualizing the organic forms of the design. (See Figure 8.4)

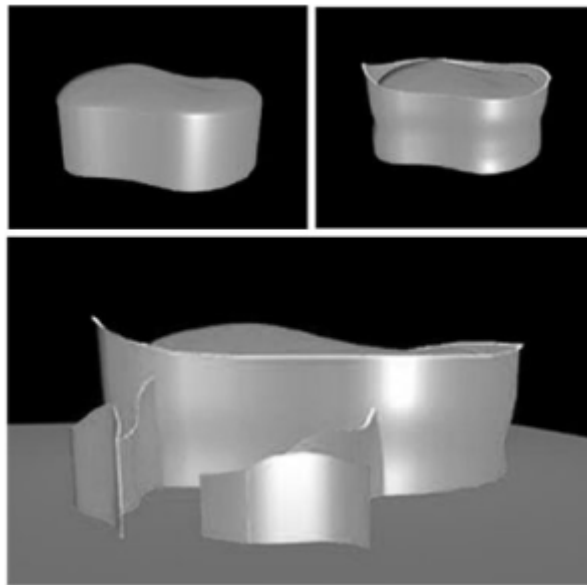


Figure 8.4: Evolution of model using NURBS Modeling

Though it took up considerable time initially, Maya proved to be an excellent tool for exploring alternatives and visualizing complex spaces formed by the curved walls and complex roof patterns.(See Figure 8.5 – 8.6) It aided exploration of forms and helped to sculpt the spaces into an organic whole.

Table 4: Conceptual Model in Maya – Time taken

Work	Approximate time spent
Tutorials on Maya Basics	30 hours
Concept development	20 hours
Conceptual model using Polygonal Modeling	30 hours
Tutorials on NURBS surfaces	10 hours
Conceptual model using NURBS Modeling	20 hours
Design Development	40 hours

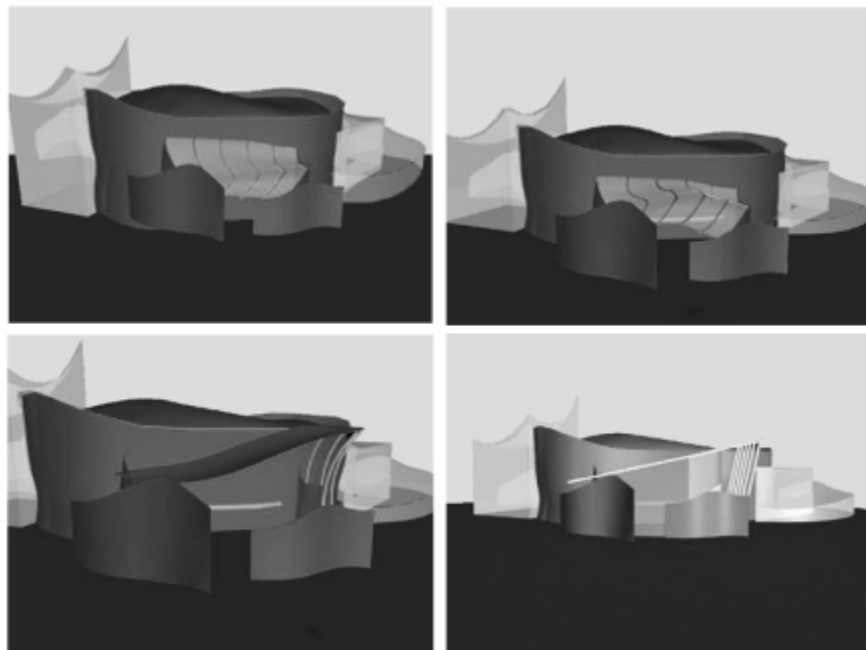


Figure 8.5: Exploring alternate roof forms using Maya

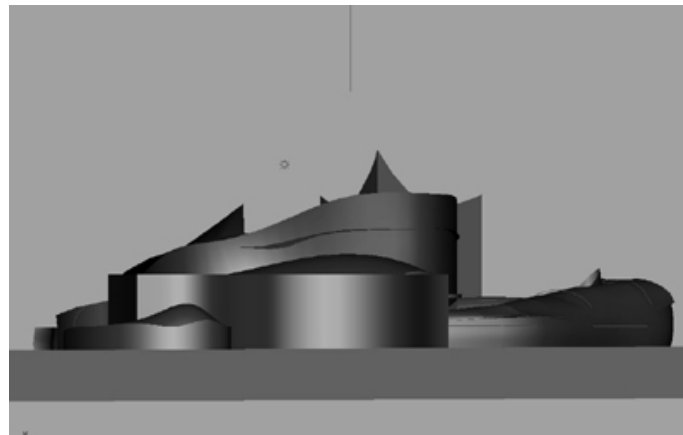
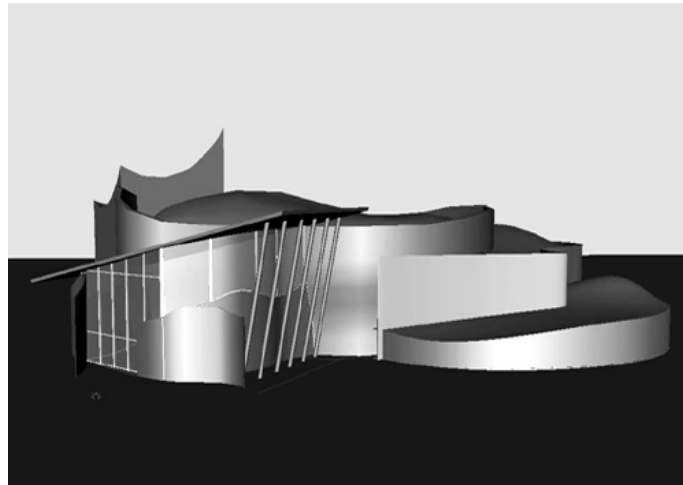
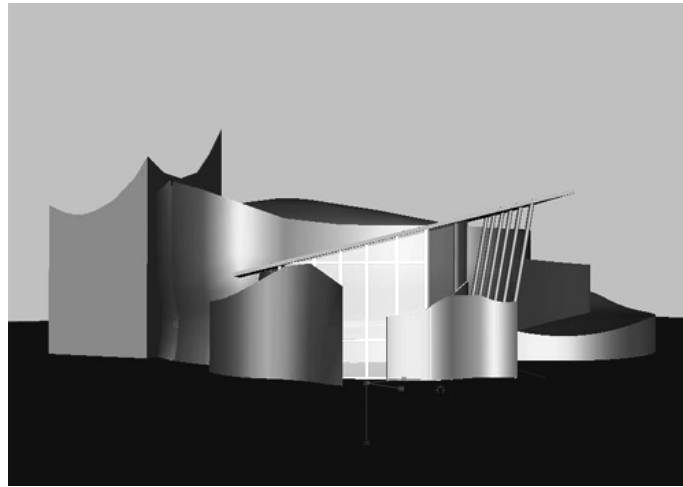


Figure 8.6: View of the conceptual models created using Maya

To explore the lighting and rendering capabilities of the software a gallery interior was visualized. The interior spaces were designed and these spaces were visualized in greater detail.

The different lighting techniques in Maya were used to explore the ambience inside the gallery. (See Figure: 8.7) A wide range of colors, materials, textures and properties like shininess, transparency, reflections and the variety of lights offered by the software were experimented. Getting the correct brightness of the lights and the play of shadows were a bit strenuous at the beginning. The basic differences between how light acts in real life and how digital lighting works had to be understood. These subtle differences and the work around to make realistic renderings takes enormous amount of time and effort. However the result gives a realistic picture of the design and saves time and resources spent on mock up studies.

Table 5: Interior rendering in Maya – Time taken

Work	Approximate time spent
Tutorials on Maya lighting & rendering	20 hours
Design development & Modeling the interiors	40 hours
Lighting the interior	30 hours
Advanced lighting and rendering tutorials	20 hours
Detailing	20 hours
Texture mapping and lighting	40 hours



Figure 8.7: Digital lighting and rendering using Alias Wavefront Maya

The design was also taken to the next level of 3D representations and used in the exploration of the latest developments in the field of rapid prototyping. (See Figure 8.8) Though these techniques have not yet gained wide acceptance in architecture they show a good potential for architectural visualization and representation purposes.

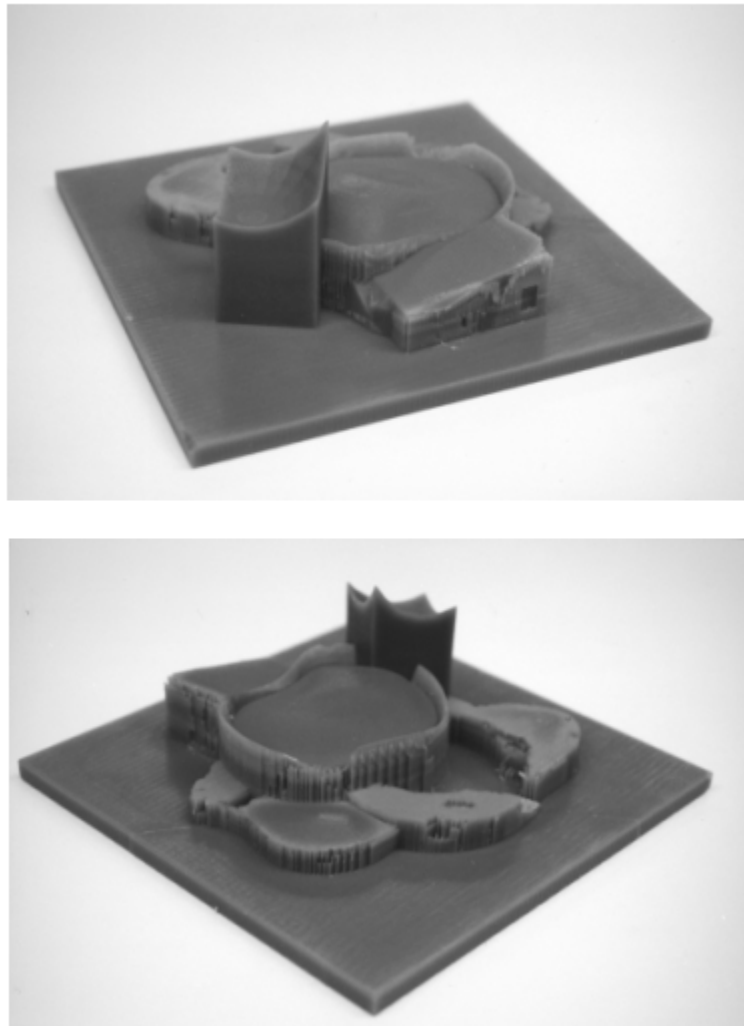


Figure 8.8: Physical model output from a 3D printer

The digital output file from Alias Wavefront Maya was translated to a stereo lithography (.stl) file and sent to a 3D printer. The printer used was a Thermojet solid object printer from 3Dsystems.⁵⁴

There were a few translation and geometry issues before printing the model. All the surfaces had to be closed without any gaps. The printer was more efficient in printing the basic geometries rather than the derived ones. There were also a few areas that couldn't be printed due to errors in the geometry and their intersections. This physical model output from the printer was however a tremendous tool for the communication of the design. It had a very neat finish which would have otherwise required meticulous work and enormous amount of time and energy. These complex forms might have been rather impossible to build so precisely in physical reality without these tools.

These technologies are still in their developing stages; however, some progressive firms are beginning to explore various aspects of 3D output potential.

SUMMARY

- High-end visualization techniques have a relatively steeper learning curve and understanding the basics of these techniques helps in making quicker progress with complex tasks.
- Maya helped to visualize and communicate the organic forms and complex spaces in the design of the museum of modern art.

⁵⁴ 3D systems, Retrieved November 10, 2002 from <http://www.3dsystems.com/products/multijet/thermojet/index.asp>

- Choosing the appropriate technique for a particular task comes through practice.
- The modeling and rendering of the interiors helped in visualizing and communicating the ambience of the gallery through realistic colors and lighting.
- Learning the software and designing simultaneously took considerable amount of time. It took around 150 hours each for doing the conceptual model and the detailed rendering.
- The application of 3D printing simplified the process of making physical models. Physical 3D models were printed directly from a thermojet printer through the input data supplied from the digital maya files.

CHAPTER IX

FINDINGS AND ANALYSIS

In the previous chapters we have seen the history of architectural representation and its transformations due to the developments in digital technology. In this chapter we will proceed to analyze these and the primary evidences gathered from the case studies and survey to establish the hypothesis,

Digital visualization techniques are showing rapid progress and great potential for use in architectural visualization. Implementation of these techniques is quite challenging, impeding their penetration into the practice of architecture.

We see from Chapter V that digital representation techniques are showing a significant variation between

- a. what is possible - Emerging technologies in Research Centers
- b. what is feasible - Hardware and Software Applications available in market, and
- c. what is practically implemented.- Current Scenario in Architectural Practice.

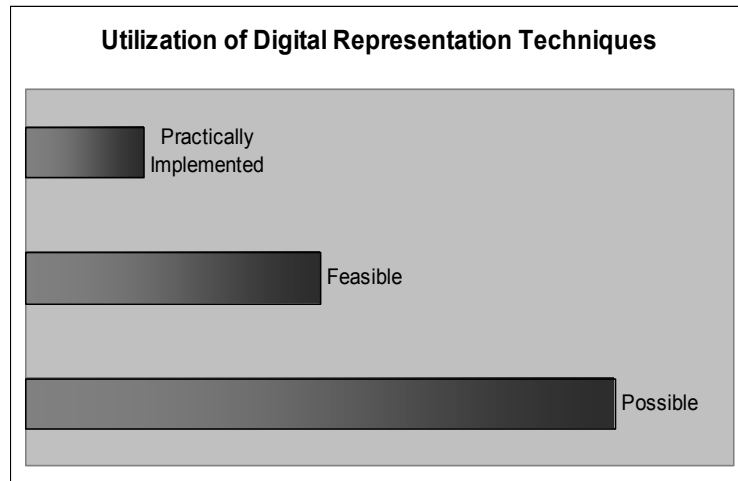


Figure 9.1: Utilization of Digital Representation Techniques

From Chapter IV we see that architects initially faced many difficulties for implementing 2D CAD. They were new to the process of digital computing and they had to learn and understand the basic concepts of the operating system, the file structure, hierarchy, and file transfer which took significant effort. While implementing 3D visualization tools we do not encounter this problem of learning to use the operating system and understanding its working. We have progressed to an extent that almost all employees in an architectural firm have a basic knowledge about the computer and its file structure and utilities, making the shift to 3D CAD much easier. (See Chapter V) However, the first CAD programs were programmed using simpler algorithms, only to display work on two-dimensional graphics. The change to three dimensional CAD involved considerable memory and much more sophisticated programming.

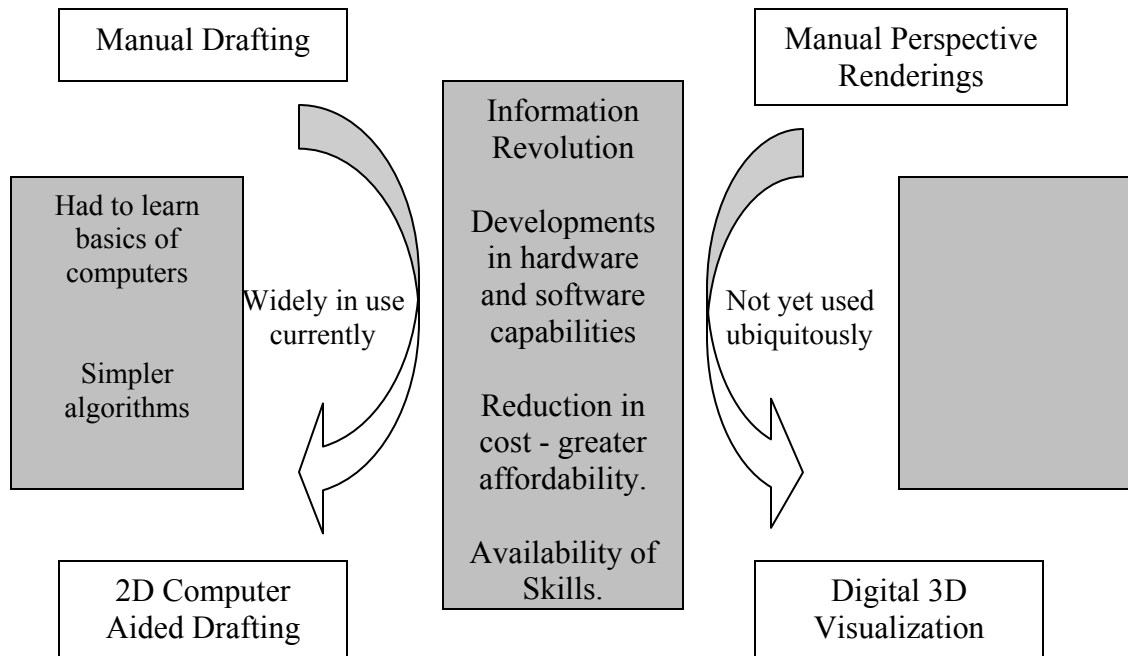


Figure 9.2: Digital 2D Drafting Versus 3D Visualization

We see from Section 4.2 that architectural visualization is trying to emulate the entertainment industry. Research and developments in the computer graphics industry is showing good progress, coming up with innovative techniques for better, faster and more realistic visualization. (See Sections 4.1 and 4.2) However, many software used in architectural representation are not designed specifically for architecture. They are designed for the computer graphics industry in common resulting in a steep learning curve. (See Chapter VIII) The applications designed for architects are more simplified, user friendly and tailored to architectural uses. (For instance the software 3DStudio Viz which was discussed in Section 4.3)

Additionally, many of these software are designed as stand alone applications serving single specific purposes. This leaves us using different applications for different phases of the design and representation resulting in translation and compatibility issues. (See Figure 5.13) There is also a wide variety of software applications available to meet each specific need. (See Figure 5.8, 5.12 and 7.2) This makes it challenging on the firm to explore the possible utilizations of the applications and make the appropriate choice of software. Proper research of the firm needs and the analysis of the features of the particular application help in making correct decisions while investing in new technologies. Each application also holds certain minimum requirements in terms of hardware requirement like processor speed, memory and compatibility with the existing operating systems and other software applications used in the production pipeline.

Software applications are constantly evolving resulting in incessant upgrades (See section 4.3) The cost of buying these upgrades and more licenses to meet the growth in the number of users develop the issues of scalability and flexibility. Software application vendors are now following the subscription business model where, software vendors lease out licenses for a yearly fee and the customers enjoy the benefit of staying current with the latest upgrades.

Each individual or firm evaluates various software solutions and trickles down to a few which suits their requirements and budget resulting in compatibility and interoperability issues while working in the collaborative team. (See Figure 5.13) There is a growing need for common standards and a comprehensive package to meet all visualization needs. This might help to avoid rework and save time and energy. The flip

side of creating a single comprehensive package will be the heavy requirement of hardware resources and steep learning curve associated with their implementation in practice.

We see from Chapters IV and V that visualization software is improving so dramatically and new techniques are flowing in resulting in frequent upgrades and complications. Each person develops his/ her own style in using these tools and the imparted training is just a base to start ones exploration. (See Chapter VIII) The online discussion forums and support from the professionals prove to be very useful considering the emergent nature of the industry and techniques which demands enormous time and effort. However, the learning curve makes it difficult to employ digital techniques when there is a shortage of time. Hence they are slow to enter architectural practice, where there is always the pressure of crushing deadlines.

For a visualizer, to make the fullest use of the technology he/she has to be proficient not only at architectural visualization but also understand the basics of the working of the particular application. (See Chapter VIII) Understanding the working of the software and hardware and their optimum use to generate quality work is also a part of the visualizer's responsibility. Hands-on experience and persistence are the key tools for coming up on the learning curve on these applications and mastering the techniques.

The contrast between the field of architecture and most other manufacturing / engineering fields is the non-repetition of the output or the product. Most architectural designs are unique thus requiring different visualization techniques; often the best method to do a job comes only through experience. (See Section 5.2 and Chapter VIII)

This makes architects reluctant to learn and experiment with the new digital tools for visualization.

Another factor to consider is that any innovation, introduced into an existing system is accompanied by an enormous resistance. A person is usually more comfortable at using a medium which he has seen and grown up with, what he has always experienced. (See Section 4.1) For the older generation of architects the computer is a new innovation and getting comfortable in the medium requires a lot of effort, interest and open mindedness.

The digitally “conservative” architects tend to argue that their individuality is lost while using digital tools. They fear that these machines will overshadow their skills. (See Section 5.2) Much like the use of filters in image editing programs, plain application of the filters might be considered mediocre work showing little or no skill but the art of maneuvering these tools and calibrating them to do what we want makes all the difference. On its own digital visualization does nothing without a human operator.

The innovations in structural and manufacturing industries are aiding the designer in the use of free flowing double helical curves and forms. (See Section 5.2) Traditional modeling methods are proving to be insufficient for visualization for such complex forms and leaning towards the digital environment provides the intuitive designer with the freedom to express and experience his designs.

In the current scenario, most digital tools available are designed for utilization towards the later part of the design process mostly in the design development and construction drawing stages.(See Figure 5.11 and Section 5.2) This is undergoing a slow

change and some new intuitive tools like “Sketch Up” are penetrating the market. The application developers are looking forward for developing more intuitive tools for the designer to bring his ideas to form. (See Figure- 9.3)

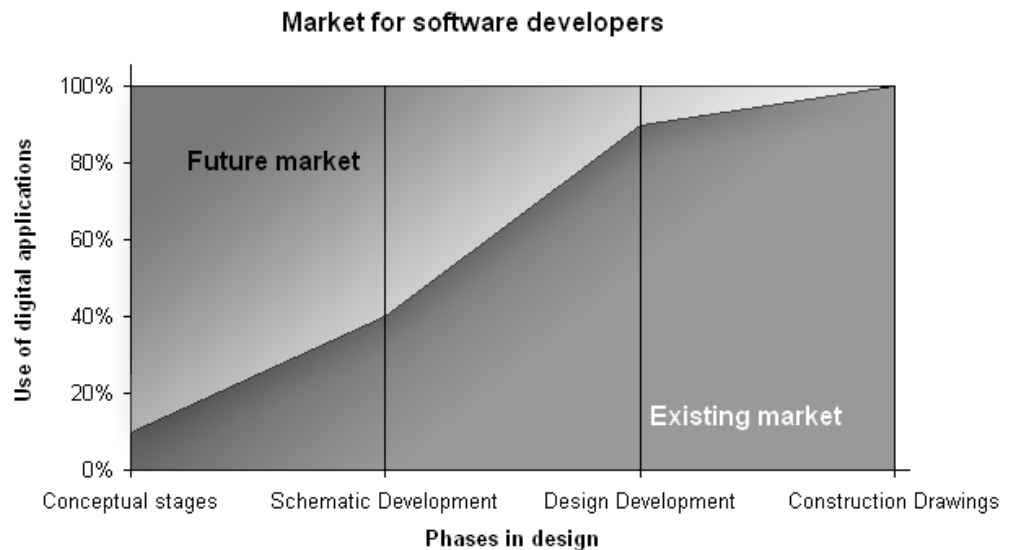


Figure 9.3: Trends in Application Development

Employing the digital medium in architecture has brought significant changes in the process of design. The different phases in design are getting amalgamated and there is no longer a clear differentiation into definite parts. The parametric modeling software further creates continuity in the whole process. (See Figure 5.11) These are being contemplated by many architects and most firms are moving toward integration of the various process of design thus blurring the distinction between the different stages of design.

Traditional representation techniques like manual renderings and physical models were typically employed during the final stages of design mainly for communication of design ideas. (See Chapter III) Digital 3D visualization is revolutionizing this process.

(See Section 5.2 and Chapter VI). Representation techniques may be employed at various stages in the process, be it at visualizing conceptual ideas by the designer, trying alternatives, competition entries, communicating the design to the client and to the collaborative team or even taking the design to the virtual world and immerse the audience in the designed virtual environment. (See Figure 9.4)

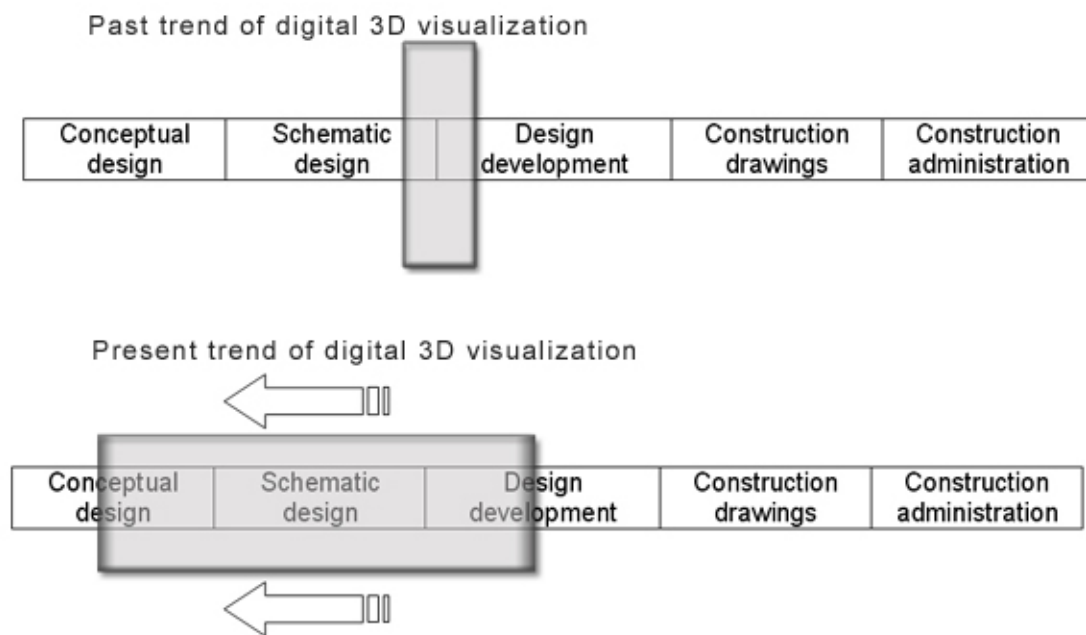


Figure 9.4: Practice trends in Visualization and Representation

In today's world the kids are taught to play with computers right from early age. The "Lego bricks" the plastic bricks and gears games which were considered to be "technic", a few years ago are bearing a depressing selling trend today.⁵⁵ The young

⁵⁵ <http://www.disenchanted.com/dis/technology/prefab.htm>

engineers no longer use these plastic bricks to create toys, rather they play similar games using the computer, dragging and dropping shapes and objects to create compositions. Their intuitions are trained to visualize in the digital medium and hence the computers do not become a mind block for their flow of ideas. However looking at the trend in the growth of the industry it is not off beam to assume that there might be much other advancements in practice in a few years.

For older generation :

medium of thinking \neq medium of expression - difficult

For younger generation :

medium of thinking = medium of expression - ease of use

The present day architecture schools emphasize the use of computers in the field and there are specializations in digital architectural visualization offered in many schools.(See Figure 4.6) A significant number of students graduate every year with expertise in a variety of digital techniques and the inception of such visualization programs in school of architecture is showing a steady increase. These students are challenged with keeping in pace with the innovative emerging trends and for bringing about a massive change in the practice of architectural visualization.

The trend in moving towards more 3D visualization can be compared to the 2D CAD revolution which made a whole procedural change in the practice of architecture. From Section 4.1 we see that during the inception of 2D CAD there were a group of CAD specialists who were proficient at using these digital drafting tools. Then the number of

computers increased and each department within a firm had their own computers. Slowly, the computers immersed in the whole office and currently almost everyone is using these digital tools for drafting.

Similarly, not very many architects are proficient in 3D CAD at present. There are a few professionals who excel at the art of digital 3D modeling. The younger generations of architects are exposed to modeling and rendering techniques as part of their architectural education and the trend shows that we are moving towards having a modeling expert working with each department or project from its conceptual stages to the final rendering stages. The implementation of parametric design applications is making it more feasible for almost all the architects and designers involved in the project to design and work in the 3D environment. There is little doubt that 3D modeling will become ubiquitous in architectural offices in the next few years.

For instance if we look at the history of CADD implementation at HKS Inc. Dallas we see that during the inception of CAD in 1983 there was a central computer lab that had four IGS workstations running CalComp systems for computer aided drafting and the CAD specialists worked on the projects which required the use of CAD .(See Figure 9.5)

In similar lines the visualization lab at present excels in meeting the modeling and presentation needs of the firm. The viz. lab is equipped with higher end machines running special graphics hardware and software which are not available in the other machines used for CAD purposes. The affordability and advancements in hardware, the increasing popularity of the laptop computers and floating licenses for software are facilitating further change in the existing system helping a visualization expert to be a part of the

design team from the initial stages of design. Currently a few disciplines, for instance the aviation and sports disciplines in HKS have a visualization expert in their design group facilitating the use of 3D tools for visualizing their designs from early stages.

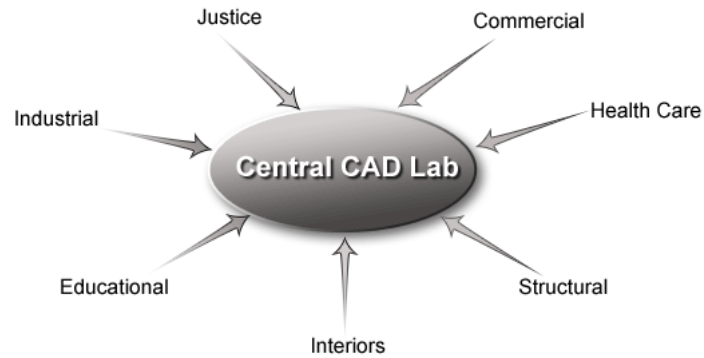


Figure 9.5: Past Trend in Architectural Practice

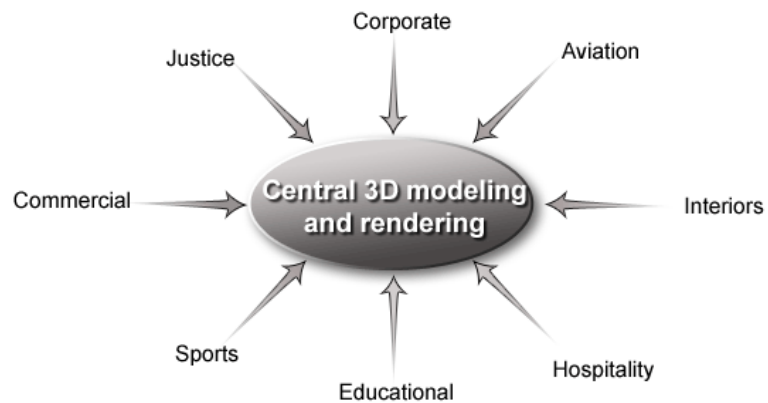


Figure 9.6: Present Trend in Architectural Practice

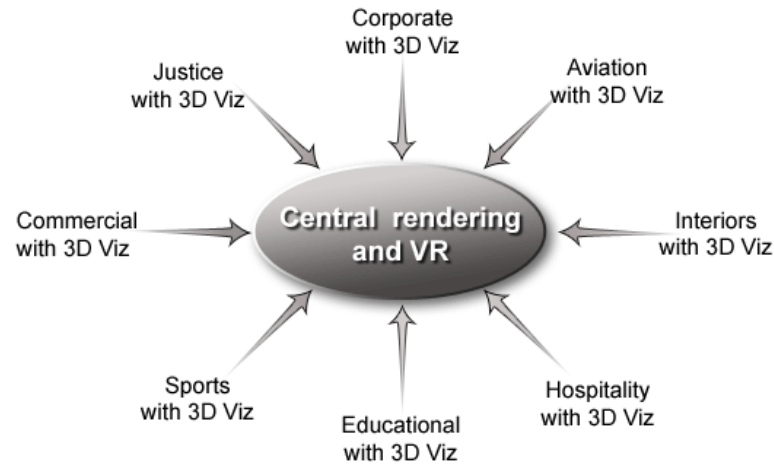


Figure 9.7: Upcoming Trend in Architectural Practice.

During the past decade the AEC industry is growing more sophisticated electronically. (See Chapter V) New methods, components, and processes are beginning to make digital images more buildable. No longer can the designer or the visualization architect deal with the process in isolation. The designer has to now consider other linked areas and have a holistic understanding of the entire production process. The output format from one phase of the design to another makes a marked difference in the other phase and the phases of design overlap leaving no clear distinction between the different phases. Earlier the visualization architect had to work from manual drawings. (See Chapter III) The manual drawings later changed to 2D CAD drawings after the immersion of CADD. (See Chapter IV) Now, in a few instances where parametric modeling software have walked their way into the design process the visualization

architect has the advantage of being a part of the collaborative team and works with 3D models which are produced as a part of the design development process.(See Chapter V)

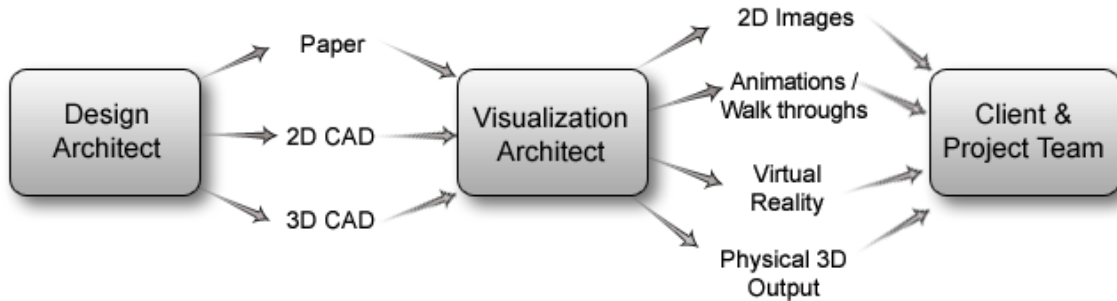


Figure 9.8: Input and Output Changes in Representation

The emerging output solutions namely the 3d printers, CNC routers, virtual reality devices and the kind also make a marked difference in the way a structure is modeled and rendered. (See Section 5.2) These technologies are in their nascent stages in the field of architecture and getting a full grasp of their efficient usage is still under experimental stages. Each technology requires a specific kind of object and an understanding of the whole process is very critical in such cases.

Visualization is definitely getting better but not easier. From Chapter VII we see that to be competent in the field of architectural visualization one should be skilled at many related visualization software and multimedia along with having basic drawing and rendering skills. A practicing architect might not have the time and capacity to look at other fields and learn. Looking at the current pace of technological acceleration one has to keep moving at a very fast pace just to maintain the current status of technical

knowledge. This makes it a perennial necessity for experts who are dedicated to constantly updating and looking out into the other fields like computer science and the entertainment industry and applying these to architecture.

The complexities associated with the digital representation are increasing with their improvements and new specialties are springing up within the field of visualization and representation. (See Chapter VII) We can see a series of interconnected services, very dependant on each other but developing as unique disciplines within visualization. These would include the lighting and rendering experts, animation experts and multimedia and composition experts and many other specialties who would work collaboratively on a piece of visualization.

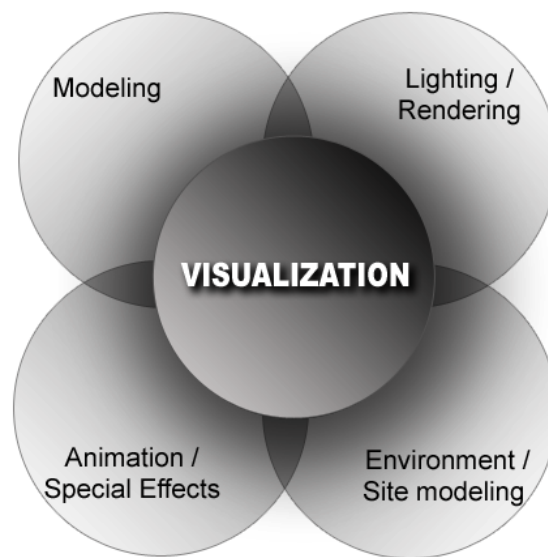


Figure 9.9: Specializations within Architectural Representation

Use of visualization and representation in the earlier stages of the design process is showing good prospects in architectural practice. The audience of the visualization effort is no longer only the client but the designers and collaborative team who make important design decisions based on this visualization. Looking at this trend it is quite accurate to assume that in future the architect will be designing in real-time in the virtual environment using just the actions of his hands and eyes.

CHAPTER X

CONCLUSION

Digital architectural visualization techniques are infusing into architectural practice creating a major breakthrough in the way architecture is visualized and represented. Employing a logical approach to selectively implement this procedural change would help in realizing the strategic benefits of these rapidly progressing representation techniques.

In the present market place the success of any architectural practice will depend on the willingness to embrace new technologies and the ability to communicate and respond to the client's needs. Thus a clear understanding of the strategic benefits of these technologies plays a significant role in elevating the value of services offered, keeping up the competitive edge in practice.

Though a few architects may still argue that unless you are a "Frank Gehry" using organic forms, there is not much use of digital visualization in practice, looking at its long term benefits a few progressive architectural practices are overcoming the psychological and economic barriers to adapt digital techniques for design visualization and representation. We are in a phase of transformation where many firms are still contemplating over the change and evaluating the benefits that it can bring to the table.

Visualization services are becoming more popular and this certainly is a sign that these services will become less expensive and more affordable by the common man in future. However, there will be more innovations and developments resulting in better means of visualization and communication of design. These innovations might again pose new challenges in the practice of architecture.

“Technology is rooted in the past. It dominates the present and tends into the future. It is a real historical movement”

- Mies Van Der Rohe, 1950

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APPENDIX A
QUESTIONNAIRE TO HKS. INC

QUESTIONNAIRE TO HKS. INC

This study on the technological developments in architectural visualization is conducted among the leading architectural firms which use digital visualization in their practice. It is undertaken as part of my master's thesis on "Advancements in the field of architectural visualization and representation and their implementation in practice."

Your participation will be of great benefit to my thesis and the community of visualization architects. I thank you for your time and effort. In case you have any questions please contact Nethra Ram Mohan at nmr19@msstate.edu (Ph: 662-325 2241)

1. When did CAD become ubiquitous in the firm?
2. When was the IT department established in the firm?
3. What is the number of full time staff working in the IT department at present?
4. What percentage of the total budget for the firm is allotted for IT?
5. How do you rank the significance of electronic visualization in architectural practice?
 - a. Critical (indispensable – the system cannot be in use without this)
 - b. Important (there will be a significant loss of customer utility)
 - c. Useful (Nice to have)
 - d. None of the above

6. When did the visualization lab start operating?
7. What is the approximate percentage of the total projects in the firm which employ digital visualization techniques?
8. What percentage of visualization projects are done in-house?
9. What is the approximate percentage of projects for which 3d visualization is being used in the following disciplines?
 - a. Aviation
 - b. Education
 - c. Health Care
 - d. Hospitality and Leisure
 - e. Sports and Entertainment
 - f. Commercial
 - g. Corporate
 - h. Interiors and Graphics
10. How is the total budget for a project split for the various phases of design?
11. What percentage of the total annual budget for the firm is allotted for visualization?
12. What is the breakdown of visualization expenses as a percentage of the total budget allotted?
 - a. Hardware
 - b. Software
 - c. Consulting/ Support
 - d. Visualization staff
 - e. Training
 - f. Others

13. What are the software that are currently in use in the visualization studio? Please specify their frequency of use
- Frequently used
 - Moderately used
 - Rarely used
14. What is the hardware setup of your newest computer in the visualization studio?
- Processor Speed
 - RAM
 - Monitor Size
 - Graphics accelerators
15. How often are the computers typically replaced in the visualization studio?
16. What is the average charge for visualization work per hour?
17. Your projects employ some of the latest techniques in the field. Where do you derive your inspiration and how do you keep in pace with the technological advancements?
18. What improvements do you see in the visualization lab five years from now?

Thank You.
Nethra Ram Mohan,
Graduate Research Assistant,
Digital Research and Imaging Lab,
School of Architecture,
Mississippi State University,
MS-39759.
Ph: 662 325 2241
662 325 0725

APPENDIX B

QUESTIONNAIRE TO ARCHITECTURAL VISUALIZATION FIRMS

QUESTIONNAIRE TO ARCHITECTURAL VISUALIZATION FIRMS

Dear Sir/ Madam,

I am Nethra Ram Mohan, a graduate student at the School of Architecture, Mississippi State University. I am doing research on architectural visualization firms. I came across your firm through cgarchitect.com and found your website really interesting. I will be glad if you can help me by answering these questions. This is solely for educational research purposes and not for commercial use. Thank You.

1. Contact Name:
2. Position :
3. Age of the firm:
4. Size of the firm:
5. What kind of backgrounds do your current employees come from?
6. What is the work process for a project? How is the work divided and accomplished?
7. What are the software used in the firm for architectural visualization projects?
8. Where are you located? Does location play a role in getting projects?

9. Are there problems in communication of the design idea between the architect and the visualizer?
10. What kind of hardware do you use for the architectural visualization projects?
11. Can you tell us about your file management – production, backup, collaboration etc?
12. How do you transfer files to and back from the client?
13. What is your average charge for work per hour?
14. What kind of skills do you look for while hiring new staff?
15. What makes your work distinguishable from others?
16. Do you believe that sophistication of the office (image, website etc) helps develop a good clientele?
17. Can you share with us some lessons you learnt through your firm's growth and development?

Thank You.
Nethra Ram Mohan

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