International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 07 Issue: 05 | May - 2023 SJIF 2023: 8.176 ISSN: 2582-3930

DIGITAL ARCHITECTURE

MOKSHA CHOURASIA , AR. VAISHALI SHARMA

IPS ACADEMY

SCHOOL OF ARCHITECTURE , INDORE.

ABSTRACT

Digital architecture is a rapidly developing field that explores the intersection between architecture and technology. This research paper provides an overview of the evolution of digital architecture, from its introduction to the present, and explores its future potential. The paper also discusses various tools and types of software that are commonly used in digital architecture and their benefits.

The paper begins by discussing the introduction of digital architecture and its historical context. It then explores the current state of digital architecture and the technologies that have facilitated its development, including Building Information Modeling (BIM), parametric design, and generative design.

The paper also examines the benefits of digital architecture, including increased efficiency and accuracy in design and construction, enhanced visualization and communication of design ideas, and improved sustainability and energy efficiency in building design.

The paper then delves into the various types of software used in digital architecture, including 3D modeling software, computational design software, and virtual and augmented reality tools. It provides a comprehensive overview of the features and capabilities of these tools and their applications in architecture.

Finally, the paper discusses the future of digital architecture and its potential to transform the industry. It highlights the role of emerging technologies, such as artificial intelligence and machine learning, in shaping the future of digital architecture and creating new opportunities for innovation.

Overall, this research paper provides a comprehensive overview of the introduction, evolution, and future of digital architecture. It explores the benefits of digital architecture and the various tools and types of software used in the field, offering insights into how this technology is transforming the architecture industry.

INTRODUCTION

The term "digital architecture" refers to the process of designing and building both virtual and real structures using digital technologies including computer modelling, programming, simulation, and imaging. The term is not limited to the use of digital technologies in architecture alone, but also includes other aspects that involve the use of digital technologies. The concept of digital architecture encompasses the use of digital skins that can display images and alter their appearance. Unlike traditional architecture, digital architecture does not necessarily require the use of actual materials like stone, glass, or wood. Instead, it relies on "sets of figures stored in electromagnetic format" to create simulations and representations of material performance.

Digital architecture goes beyond creating visual spaces; it can also create places for human interaction that do not necessarily exist in physical space. It allows for complex computations that enable engineers to create complex forms easily using computer algorithms. The use of architectural design software, such as Rhinoceros Grasshopper Plugin and Bentley's Generative Component, enables architects to produce complex free forms by abandoning traditional shapes.

Digital architecture also allows for the creation of simulations that illustrate the behavior of structures and shapes. The use of 3D modeling software makes it possible to create structures in non-traditional forms. This has opened up new possibilities for designers, who can create structures that were previously impossible to build using traditional methods.

The use of simulations also allows architects to design structures that meet specific performance parameters. This can be achieved by assessing factors such as climatic conditions, costs, and ecology. By using digital technology, architects can design structures that are not only aesthetically pleasing but also functionally efficient.

The use of digital technology has also revolutionized the use of traditional materials such as stone, glass, and wood. These materials can now be used in new and unconventional ways, creating structures that are both unique and functional. Digital architecture has also led to the creation of new materials that can be used in the construction of buildings.Digital architecture has the potential to change the way we think about architecture, and it will continue to shape the field for years to come.

- **PRIOR TO DIGITALIZATION , ARCHITECTURE**

The speed of architecture was much slower before the advent of digitalization. Digital media use in architecture has also provided solutions to a number of worldwide problems. Modern technology has allowed the science of architecture to progress from a need to a luxury. Earlier, architects were known for their mastery of hand-drawn designs and sketches. Architects created specific land layouts by hand after carefully considering the needs of the clients that approached them. Since painting and words were the main forms of communication, the designs were constrained by the kinds of materials accessible.
In order to transform ideas into reality, architects also had to rely on countless interactions with other architects. The initiatives back then were lengthy and ongoing. Redesigned plans or reconstruction were simply out of the question due to cost. Prior to the digital transformation, architecture aimed to create what the customer needed rather than something novel and unfamiliar. Therefore, having repeating designs and concepts was natural. Structures' quality was not diminished. This is the reason why historic buildings continue to be revered today.

- **THE DIGITALIZATION ERA**

In the 1990s, digital architecture began to grow. For the Guggenheim Bilbao in 1990, Frank Gehry and the innovators in his company adopted digital architecture. The things they had hoped to accomplish back then were constrained. With the aid of technology advancements, there are a lot more options for architecture now than there were 32 years ago. At this time, some examples of extended assistance for architects

include virtual reality (VR), augmented reality (AR), artificial intelligence (AI), building information modelling (BIM), etc.

Software like Autocad, Revit, Sketchup, and others are taught to and encouraged for architecture students to utilise in order to more easily learn, comprehend, and visualise the scope of architecture. Young architects can experiment and explore the different design variations that are possible with the aid of this programme. Construction techniques that are quicker and simpler are now possible thanks to digitalization. An architectural project requires continual communication to run smoothly. owing to the most recent technologies, the global communication network between architects, engineers, and construction workers. As a result, architects can communicate with their coordinating team.

- **FUTURE DIGITAL ARCHITECTURE**

Future architecture is anticipated to focus on user comfort and minimising environmental harm. Future spaces are envisioned by architects as being minimal, futuristic, modular, and adaptable. In the future, problem-solving will be done concurrently with design in generative designs. Future generations are predicted to be productive, and since digital software eliminates the majority of requirements, projects may not require the involvement of many individuals in the future. Since digital visualisation makes it simpler for the client to communicate with the designer, customers will be happy. Future generations of designers will find it simpler to adjust to the professional practise of architecture since older designers will be more willing to accept the younger generation.
The use of computers in architecture creates more opportunities for employment in the sector. Continuous mentoring is necessary for graphic design, 3D modelling, visualisation, and rendering. The digitalization of architectural spaces also enables individuals to freely select and visualise their preferences prior to construction, resulting in happy clients. Construction stages may be monitored carefully to reduce errors and increase quality with the use of technology. Material procurement can be controlled likewise to prevent wastage.

The precise creation of intricate architectural models and floor plans is made possible by digital architect tools.

In order to meet the sophisticated requirements of the modern building business, architecture firms are using new technology in the form of software programmes and gadgets.

Historically, floor plans, blueprints, and models of buildings were all created by architects using ink and paper. These hand-drawn designs were kept in physical form and distributed to clients. However, problems like lost documents and incorrect measurements forced architects to search for effective solutions.

Over time, architects began to embrace technology and digital technologies. Modern architecture firms use a variety of digital tools, from design tools to workflow management software, to precisely generate intricate building models

and floor plans. Additionally, these solutions aid in project workflow management to guarantee on-time completions.

What are tools for digital architects?

Tools for digital architects might be anything from software programmes like design and project management systems to electronic devices like electric pencils. Technology devices and software tools combine to enhance and improve the architectural design process. Here are a few illustrations of the most popular tools for digital architects.

Gadget	Software
Drawing designs or building models without using paper is possible with a 3D pen. You can draw on any surface using plastic ink using it to make objects.	You can develop and arrange architectural designs with architecture software. By automatically assigning tasks to team members and monitoring their progress, it aids in the management of everyday operations.
Wearing virtual reality goggles enables you to explore a structure virtually before it is finished.	On a computer or mobile device, you may generate 2D and 3D structural building models, floor plans, blueprints, and more using 3D architectural software.
You can select colours from any surface and use them in your architectural design thanks to a portable colour digitizer.	Using 3D CAD software, you can design 3D buildings. It also facilitates the automation of procedures including reviewing design flaws, sketching, and drafting.

BENEFITS OF USING DIGITAL ARCHITECT TOOLS –

Saves time and money

The built-in templates in digital architect software save architects from having to start from scratch. Additionally, all design tools are provided in a single software package, which reduces expenses and saves time.

Minimises the project lifecycle

Access to design tools on demand expedites the conclusion of architectural projects. From project planning and design through construction operations, project delivery is centralised.

Decreases design blunders

Building models with precise measurements and extensive geometric requirements can be produced using digital architectural tools. Any design flaws can be discussed and addressed prior to the start of construction.

Facilitating modular construction

Visualisation makes it easier to define minute design aspects, make adjustments, and assure correct measurements. It cuts down on the time and work required to recreate an in the event of a design error, the entire model.

Here are the top architectural software programmes that are frequently used in the construction industry to create a variety of outputs, including plans, 3D models and designs, interior and exterior designs, rendered images and videos, landscape planning and designs, and use for building information modelling and energy simulation, among other things.

1. **AutoCAD**

The majority of 2D drafting projects, including plan, elevation, section, etc., are done in AutoCAD. There are additional 3D modelling features, although they are less popular due to their complexity and straightforward design. It includes every aspect needed to finish a drawing in an organised and skilled manner. Architects, engineers, designers, drafters, and construction experts, as well as individuals working in the public and private sectors, make up a sizable portion of AutoCAD's user base.

2. **Sketchup**

Specifically used for architectural planning and modelling, Sketchup is a three-dimensional modelling and rendering programme. Originally owned by Google, Sketchup has since been purchased by Trimble. Its inclusion of all architectural characteristics and choices lends the 3D model some originality. Both a free and a premium version are available; the paid version has more options and features.

3. **Autodesk 3DX Max**

Software from Autodesk called 3DX Max is also used for designing and planning buildings. Autodesk 3DX Max software is mostly used for graphic design, animation, and video games. 3DX Max is renowned for its excellent animations and design. This software is used by architects for a variety of tasks, including 3D modelling, animation, interior and exterior design, object modelling, etc.

4. **Autodesk Revit**

Autodesk Revit is design software that includes all the elements needed for planning and creating buildings. It was created specifically for BIM, or building information

modelling. It contains all of the features and tools necessary to deliver flawless 3D modelling, which covers all building information, including architectural details, structural details, reinforcing details, mechanical details, plumbing details, electrical details, and other aspects related to other services, among others.

5. **Lumion**

To render 3D modelling with excellent finishing, Lumion is employed. To create amazing photos, films, and 360-degree panoramas, Lumion is typically combined with other 3D modelling programmes like Autodesk 3DX Max, Revit, AutoCAD, Blender, etc. Software is simple to operate. The software is purchased.

6. **V-Ray**

Several architecture software programmes, including 3DX, Maya, Revit, Sketchup, Rhino, etc., utilise the 3D rendering extension known as V-ray. Buildings' interior and exterior design uses it. Additionally, it is employed in the fields of software development, video games, visual effects, and product design.

7. **Photoshop**

One of Adobe's most potent products for the graphic design sector is Photoshop. Photoshop is a well-liked programme for manipulating and enhancing digital photographs. Photographers, graphic designers, and digital artists all use it. It is a premium piece of software with a variety of licencing choices, from a single app subscription to the entire Creative Cloud suite.

8. **Grasshopper**

The designer can build a comprehensive library of previously used concepts and elements using Grasshopper. With a mouse click, you can reach these modules.The fact that Grasshopper is open source software has additional advantages. It has a community in its vicinity that often creates new plugins. Additionally, Grasshopper has a close relationship with Rhino 3D. Rhino 3D may be used without having to grasp coding thanks to this interface.

9. **Dynamo**

Dynamo often includes a free plugin for Revit. This means that you have the choice to use it in addition to Revit, albeit doing so will cost you money each month. You can quickly update your designs with Dynamo. You can also immediately change your designs. The software also accommodates a large number of file kinds.

10. **Fusion**

Fusion software provides a comprehensive remedy. In addition to designing and testing, the programme can be used for manufacture. One of the few tools that can assist you in producing realistic representations of your designs is Fusion 360. This helps clients visualise your work or when giving presentations. One of the design software programmes with the most support is Fusion 360.

BENEFITS OF COMPUTATIONAL DESIGN IN ARCHITECTURE

After the introduction of computers, human beings have seen their power to calculate and accomplish several complicated jobs at a time. The internet has brought the entire world to our fingertips in the twenty-first century. Computational design refers to the use of computers and specific algorithms, which has had a significant impact on architecture. Through computational design, we can generate complicated geometry using a mathematical approach and consequently explore with possibilities through parameters and limitations. The advantages of computational design in computational architecture are as follows:

1. Precise drafting and improved renderings of AR/VR .

The traditional method of managing a project involves spending a significant amount of time creating construction drawings.3D modelling and visualisation software is crucial to the advancement of computation in the field of architecture. Today's architectural representation has advanced to include Virtual Reality and Augmented Reality technology in addition to 3D models and views. It facilitated better modelling and rendering for the architects and visualizers as well as improved client interaction with the desired space.

Figure 1 View of the drafting studio ,1942 , Albert Kahn Associates

Figure 2 Using VR technologies in presentations

2. Using algorithms, create a spectrum of potential outcomes .

A computer is a machine that understands machine language, software developers help to design or set the algorithm of the machine in a way so that any human may interact the computer speaking human language rather than 0 and 1. Therefore, creating codes or defining certain algorithms can aid in the production of the outcomes we desire. So, using this outcome, one can build visually beautiful complicated forms and also digitally fabricate them.

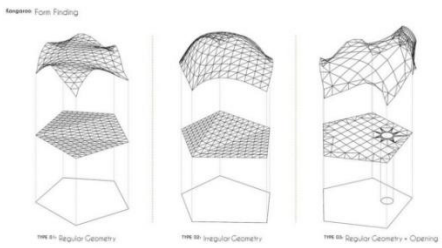

Figure 3 Form finding through kangaroo visual coding

3. Ease of documenting at various levels.

A project needs to be thoroughly documented so that people can learn from their past mistakes, consult the information when needed, and assist with project maintenance. Computation allows for the systematic directory storage of project information as well as the well-organized retrieval of that information.

4. 3D printing in a range of sizes.

3D printing is one of the key applications of 3D modelling. Utilising 3D printers, shapes and forms that are impossible to model by hand may be done so with only one click. Building installations, residences, experimental structures, and many other things were made possible thanks to 3D printing. Few construction businesses have begun using 3D printing in the sector of architectural construction, which is still in the development stage.

Figure 4 3D Printed House

5. 3D scanning and ease in surveying .

An important task that is completed for the site where construction will take place is the surveying of lands and topography. Survey data can be obtained more precisely and with more information by using 3D scanning and imaging technology. Drones with AI can accurately survey the site even though there may occasionally be many inaccuracies due to harsh weather or particularly hard terrain.

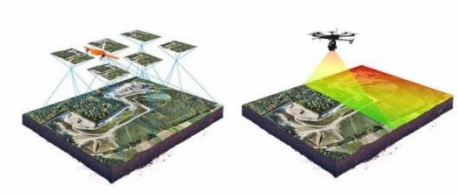

Figure 5 Drone used in scanning of topology

6. Integration of BIM.

The BIM technique is distinct from the conventional method of building construction. The computer is crucial in coordinating all the work, communication, and documentation at once. The computer also aids in aligning the project timeline with the work being done on the ground.

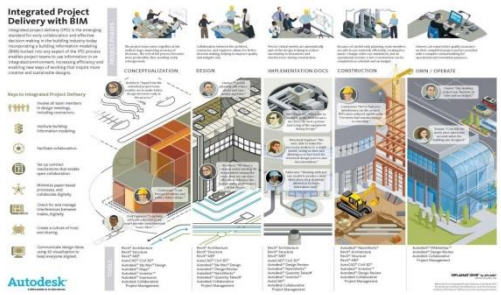

Figure 6 Use of BIM at different stages of a project

7. Allow various simulation types.

Simulations are a wonderful technique to evaluate the designs and significantly improve them. We work on a variety of simulations, including structural, wind tunnel, earthquake, green building, and energy models, among others. These facts assist the designers in problem-solving and the development of practical solutions prior to construction.

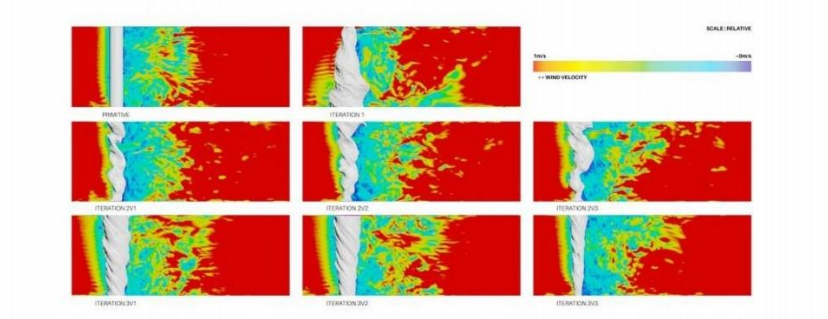

Figure 7 Wind analysis of structure's elevation

8. A better risk analysis and project management system.

Software for project management and scheduling is crucial for monitoring progress and coordinating with previously created schedules. Computers can also be used to estimate building expenses and identify potential risks prior to construction.

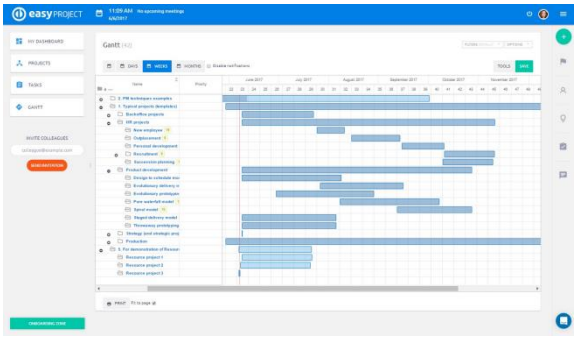

Figure 8 Digital project management system

9. Using AI and robots in architecture.

Although it is still in the development stage, robots and AI are rather new in architecture. We live in a world where there are numerous types of robots and AI-based mechanisms in use. Robotic arms are used for 3D printing and form fabrication, and AI mechanisms are used to produce an error-free, high-quality design more quickly.

Figure 9 Use of robotic arms to digitally fabricate objects at University of Stuttgart

10. Intelligent Building Management Systems .

In order to manage the building's service systems, energy usage, and other factors, intelligent building management systems are widely used in skyscrapers and high-rise apartments. This technology improves the building's sustainability, lowers maintenance costs, and gives building occupants a better quality of life.

Figure 10 Intelligent building management system

These are the select few domains where computational design has been beneficial and added a new dimension to architecture. As we advance towards the future, the computer will help us in the betterment of human beings and improving our lifestyles.

DIGITAL ARCHITECTURE IN FUTURE

The future development of digital architecture is constantly evolving with the rapid advancements in digital technologies. The use of advanced software has provided architects and designers with new tools to design, simulate, and analyze complex structures with ease. One of the major advantages of digital architecture is the ability to design structures that were once impossible to build with traditional methods.

With the use of 3D printing and other advanced manufacturing techniques, architects can create intricate and complex designs that were once thought to be impossible.

Digital architecture also provides the ability to simulate and analyze a building's performance in real-world conditions, such as environmental factors, energy consumption, and structural stability. This allows architects to optimize designs to achieve maximum efficiency and sustainability, reducing the environmental impact of buildings.

Another advantage of digital architecture is its ability to streamline the construction process, minimizing errors and reducing construction time and costs. The use of Building Information Modeling (BIM) software has revolutionized the construction industry, allowing architects and contractors to collaborate and coordinate more effectively.

The future of digital architecture is also likely to include the use of augmented reality (AR) and virtual reality (VR) technologies, allowing clients and designers to visualize and experience buildings before they are constructed. This will provide new levels of interactivity and feedback in the design process.

The uses of digital architecture are not limited to just the construction of buildings. The technology can also be applied to urban planning, interior design, product design, and even art installations. As the technology continues to evolve, the possibilities for its use will only expand.

Overall, the future of digital architecture is bright, with new developments and advancements on the horizon. The benefits of this technology are numerous, and its uses are only limited by the imagination of architects and designers.

CONCLUSION

In conclusion, this research paper provides a comprehensive overview of digital architecture, from its introduction to the present, and explores its future potential. Digital architecture has emerged as a critical field of study at the intersection of architecture and technology.

The paper traces the historical evolution of digital architecture and its impact on the architecture industry. It highlights the various tools and types of software that are commonly used in digital architecture, such as BIM, parametric design, generative design, 3D modeling software, computational design software, and virtual and augmented reality tools.

The benefits of digital architecture are numerous, including increased efficiency and accuracy in design and construction, enhanced visualization and communication of design ideas, and improved sustainability and energy efficiency in building design. The use of digital architecture also allows for the creation of responsive and adaptable buildings that can respond to changing user needs.

Looking to the future, emerging technologies such as artificial intelligence and machine learning are expected to play a significant role in shaping the future of digital architecture. These technologies have the potential to revolutionize the field and create new opportunities for innovation and creativity.

In summary, digital architecture has transformed the architecture industry, providing architects with new tools and techniques to create sustainable, efficient, and innovative buildings. The future of digital architecture is bright, and we can expect to see continued growth and innovation in this field in the years to come.

REFERENCE

1. https://space10.com/project/digital-in-architecture/
2. Kolarevic, B. (Ed.). (2003). Architecture in the Digital Age: Design and Manufacturing. New York, NY: Spon Press.
3. Burry, M. (2011). Scripting Cultures: Architectural Design and Programming. New York, NY: John Wiley & Sons.
4. https://cpl.thalesgroup.com/software-monetization/benefits-of-digital-transformation
5. Oxman, R., & Oxman, R. (Eds.). (2014). Theories of the Digital in Architecture. New York, NY: Routledge.
6. Menges, A., & Ahlquist, S. (Eds.). (2011). Computational Design Thinking. West Sussex, UK: John Wiley & Sons.
7. Schodek, D. L., Bechthold, M., Griggs, K., Kao, K., Steinberg, M., & Wan, W. (2004). Digital Design and Manufacturing: CAD/CAM Applications in Architecture and Design. New York, NY: John Wiley & Sons.
8. file:///C:/Users/Acer/Downloads/30500-75803-3-PB%20(2).pdf
9. https://www.researchgate.net/publication/354214529_STUDY_OF_DIGITAL_ARCHITECTURE_TECHNOLOGY_THEORY_AND_DEVELOPMENT
10. Menges, A. (Ed.). (2012). Material Computation: Higher Integration in Morphogenetic Design. West Sussex, UK: John Wiley & Sons.
11. https://www.capterra.com/resources/architect-tools/
12. https://www.re-thinkingthefuture.com/2020/12/19/a2563-10-benefits-of-computational-design-in-architecture/
13. https://www.re-thinkingthefuture.com/2021/06/25/a4341-10-books-related-to-generative-architecture-everyone-should-read/