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A Study on the Awareness of Artificial Intelligence in Architectural Design

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Abstract

Artificial intelligence (AI) has become an increasingly integrated part of our daily lives, from the personalized recommendations we receive on social media to the virtual assistants like alexa, google ai, siri etc that help us manage our schedules, we use AI in ways more than we actually know of. So, as AI technologies continue to advance, its impact on our lives will only continue to grow. The aim of this research paper is to try and approach this technology through an architect's perspective and look at both the potential positive and negative impacts that it can have on an architect's life. As professionals and as students, architects also use AI in almost every design stage. Be it the AI built in the software they use to create designs, plans, 3-D models etc or the AI they use in searching for the proper case studies and inspiration on google. This paper focuses on exploring the ways in which AI can enhance the design process by facilitating faster and more effective conceptualization, and to provide a comprehensive overview of the recent technological developments in this area. The survey highlighted that most people agreed on AI affecting an architect's job, and the ones who didn't were either established architects or ones form the non-architecture background. Therefore, it is better to include AI in college's curriculum and have young architects get accompanied with this technology because AI might not replace an architect but a professional who knows AI will.

Keywords: Artificial Intelligence, Architecture, Architectural design, Conceptualization

Introduction

In the mid 60's, Charles Eastman started researching on BIM technologies by developing building product models which aimed to create a unified digital 2-D and 3-D representation of a building's components. In 1982, there was a groundbreaking transition to an architect's profession when Autodesk released Autocad. This was followed by Graphisofts's ArchiCad in 1987 that allowed virtual building modelling. This not only lead to a better efficiency but provided the architects unparallel precision, significantly more design possibilities, and helped minimizing errors while making the iterations in a design process easier. Ultimately, the next big step was the foundation of REVIT which was acquired by Autocad in 2002 and became almost an industry standard by providing better integration with other fields like structure, plumbing etc.

Now with the introduction of Artificial intelligence in the recent years, it is bound to affect an architect's profession too. Similarly, as CAD tools left architects with skepticism about their jobs and value of the software, the same is bound to happen with AI. With this technology, the field of architecture has significantly transformed the traditional approaches to design, visualization, and conceptualization. The utilization of AI-based tools has enabled architects to create more innovative, sustainable, and efficient structures. This paper firstly aims to understand what AI actually is and how exactly does it work before further diving into the topic of AI helping us create better, quicker and more beautiful designs.

AI in architecture can enhance the visualization and efficiency of architectural designs. AI- powered tools can create realistic renderings of buildings, allowing architects and clients to visualize the design before it is built. This enables clients to provide feedback and make changes to the design before construction

begins, reducing the risk of costly mistakes and delays. Furthermore, AI algorithms can generate design options based on predefined parameters and constraints. By automating the initial design generation phase, architects can quickly explore a wide range of possibilities without manually creating each design iteration, saving significant time and effort. Also, AI can analyze large datasets of existing architectural designs to identify patterns and commonalities. By analyzing historical designs and architectural styles, AI algorithms can provide architects with valuable insights and recommendations during the design process. Based on these datasets and the survey conducted this paper explores the general perception of AI in the Indian architectural landscape while also exploring its possible advantages and disadvantages.

Literature Review

In recent years, the integration of Artificial Intelligence (AI) into architecture has gained significant attention from researchers and practitioners. AI techniques have been used to enhance and streamline various aspects of architectural visualization, such as 3D modeling, rendering, and animation. One area of focus has been the use of AI algorithms for generating realistic 3D models of buildings from 2D drawings or photographs. This has been achieved through the application of machine learning techniques, such as deep learning and neural networks, which can learn to extract features and patterns from images and transform them into 3D models. Visualization of a space, be it real or imaginary has been a very important part of architectural education and practice. This is one of the best ways for an architect to convey their ideas and communicate their abstract concepts to the viewer. As a result, architecture, especially in its initial stages is experienced more through photographs and drawings than from personal experience. (1)

AI has also been used to optimize the rendering process, improving the efficiency and realism of rendered images. For example, AI techniques have been used to predict the lighting conditions and generate realistic shadows and reflections, reducing the need for manual adjustments. Furthermore, A.I. has been used to create interactive and immersive architectural visualizations, such as virtual reality environments, which provide a more realistic and engaging experience for clients and stakeholders. AI in architecture refers to the application of Artificial Intelligence to assist architects in the design process, from conception to construction (AI can be utilized in all 6 phases of the architectural design process. This involves several stages, including Pre-Design, Schematic Design, Design Development, Planning Application, Construction Documents, and Construction Administration. AI can increase architectural design efficiency and assist with mundane tasks in the design process such as design prototyping, risk management, and cost control. AI text-to-image (TTI) software like Midjourney, DALL-E and Stable Diffusion has the potential to change the way that architects approach the creation and concept stages of designing buildings and products. A TTI refers to a technology that involved the generation of visual content through textual descriptions also knows and promts. These generations can be in the form of images, graphics or even short gifs, that can further be combined to form a video and can reduce “thought-to-execution delay” significantly (2). AI has the potential to revolutionize architecture and construction in various areas, including the design process, efficient usage of space, and providing solutions to overcome safety and cost concerns. However, it is essential to weigh the benefits and drawbacks of using AI in architecture carefully. Overall, the integration of AI into architectural visualization has the potential to revolutionize the industry, making it faster, more efficient, and more accessible to a wider audience. Before understanding what impacts these AI tools can have, its important to understand what AI actually is and how it works to generate these visual representations. Artificial Intelligence (AI) is a field of computer science and engineering that focuses on creating intelligent machines that can perform tasks that typically require human intelligence, such as visual perception, speech recognition, decision-making, and natural language processing. (3) The term "Artificial Intelligence" was first coined in 1956 by John McCarthy, Marvin Minsky, Nathaniel Rochester, and Claude Shannon during the Dartmouth Conference, which was the first major AI conference. Since then, AI has become an increasingly important field with many applications in industries such as healthcare, finance, and transportation, among others.

The Dartmouth Conference was a seminal event in the history of AI, where researchers, including John McCarthy, Marvin Minsky, Nathaniel Rochester, and Claude Shannon, discussed the possibility of creating intelligent machines that could learn, reason, and perform tasks like humans. From there, the field of AI has grown and evolved into a diverse and complex discipline with many applications across industries. Artificial intelligence in itself if categorized into 3 major parts-

(1) Artificial Narrow Intelligence (ANI) – Specializes in one area and solves one problem (Machine Learning)

(2) Artificial General Intelligence (AGI)- Refers to a computer that is as smart as a human across the board (Machine Intelligence)

(3) Artificial Super Intelligence (ASI) – An intellect that is much smarter than the best human brains in practically every field (Machine Consciousness) [4]

As mentioned before, AI (Artificial intelligence) in itself is a massive topic. This paper discusses on the image generating models that work under a subfield of AI known as Machine Learning. It is the most common form of AI systems that can be found in the market right now. Machine learning is a subfield of artificial intelligence (AI) that focuses on developing algorithms and statistical models that enable computers to learn from and make predictions or decisions based on data. In other words, machine learning involves teaching computers to recognize patterns and relationships in data, and to use that information to make decisions or predictions. These algorithms are designed to automatically improve their performance over time, without being explicitly programmed to do so. This is done by using statistical techniques to identify patterns in large data sets, and then using those patterns to make predictions or decisions. The main difference between AI and machine learning is that AI is a broader field that encompasses a range of techniques and approaches to developing intelligent machines, while machine learning is a specific subfield of AI that focuses on developing algorithms and statistical models that enable computers to learn from and make predictions or decisions based on data. [5]

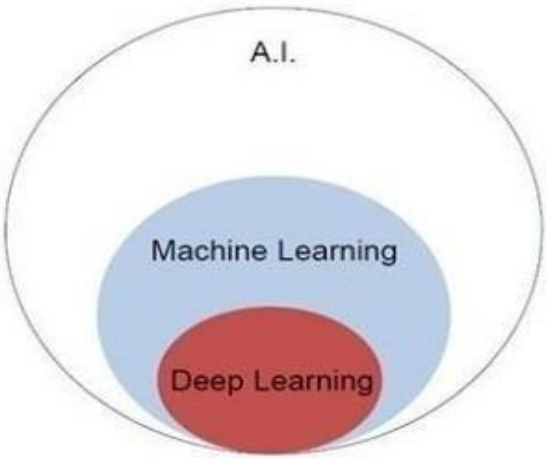

Fig. 1. Artificial intelligence and machine learning

These algorithms are designed to automatically improve their performance over time, without being explicitly programmed to do so. This is done by using statistical techniques to identify patterns in large data sets, and then using those patterns to make predictions or decisions.

The main difference between AI and machine learning is that AI is a broader field that encompasses a range of techniques and approaches to developing intelligent machines, while machine learning is a specific subfield of AI that focuses on developing algorithms and statistical models that enable computers to learn from and make predictions or decisions based on data. The creation of an architectural design typically follows a series of steps that guide the design process.

The process of designing consists of multiple steps, but when considering it as a whole, designing can be categorized into the following subparts:

1. Conceptualization - Making a rough concept of the design you're trying to create. Can be abstract.
2. Planning – Creating master plans, floor plans etc
3. Modelling – Turning these 2d- drawings into 3d models
4. Rendering – Creating realistic Renders to properly communicate your designs
5. Post production – Turning these realistic renders into proper visualization images

Before the advent of computers, architectural design was primarily done by hand. Architects and artists would use traditional drawing tools such as pens, pencils, and markers to create detailed drawings and renderings of buildings, landscapes, and interiors. These drawings would often be made on large sheets of paper or drafting film and could take days or even weeks to complete. Now, architectural visualization has become much more advanced and efficient. Computer-aided design (CAD) software allows architects and designers to create 3D models of buildings and spaces, which can then be rendered into photorealistic images and animations. These models can also be used for virtual reality experiences, allowing clients and stakeholders to explore and interact with a space before it is even built.
Now that we've understood what architectural design is, and how CAD softwares have aided architects to a great degree. But still, for even for one single room design, the architect has to make plans, models and then have to render it in order to achieve a desired presentable result. And these processes need to be done even at the conceptual stage which are again, time taking. Images can be produced using machine learning through a technique called generative modeling. In generative modeling, a machine learning algorithm is trained on a dataset of existing images, and then used to generate new images that are similar in style or content to the original images. One popular approach to generative modeling is called a Generative Adversarial Network (GAN). GANs consist of two neural networks: a generator network, which generates new images, and a discriminator network, which evaluates whether an image is real or generated. The two networks are trained together in a process called adversarial training, where the generator network is trying to produce images that can fool the discriminator network, and the discriminator network is trying to correctly identify which images are real and which are generated. There are 4 major technologies through which a design can be generated.

They are:
(1) Deep learning techniques: Deep learning is a type of machine learning that uses artificial neural networks to learn from data. It is particularly useful for processing large amounts of unstructured data, such as images, audio, and natural language text. Deep learning techniques are widely used in applications such as computer vision, speech recognition, and natural language processing. [6]

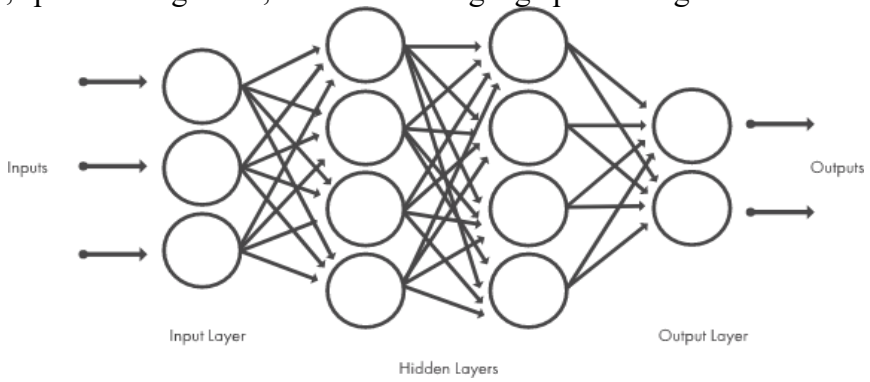

Fig.2. Deep Learning Techniques (Source : https://www.researchgate.net/figure/Diagram-of-a-neural-network-Each-circle-represents-a-simple-processing-unit-a-node-or_fig1_373475210)

(2) Generative modeling: Generative modeling is a type of machine learning that involves learning the underlying probability distribution of a dataset and then generating new samples from that distribution. This is in contrast to discriminative modeling, which is concerned with classifying or labeling input data.

Generative modeling has applications in fields such as image generation, text generation, and music generation. (7)

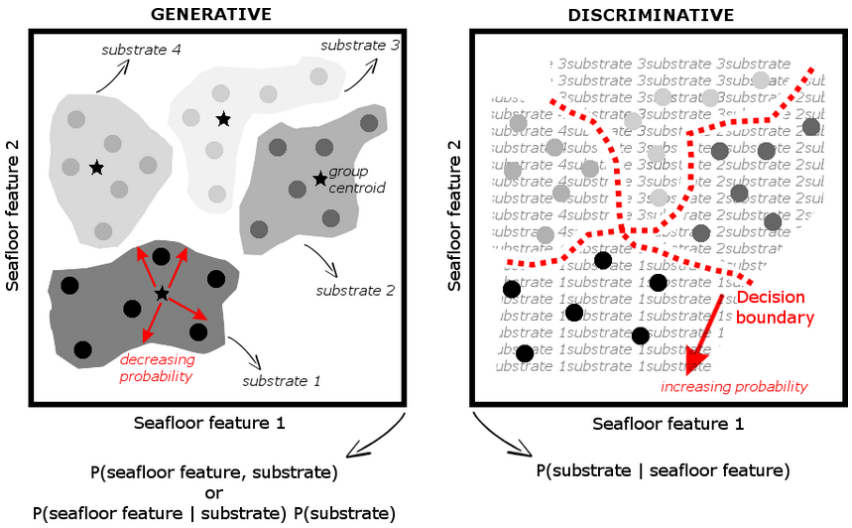

Fig.3. Generative Modeling (Source : https://www.researchgate.net/figure/Schematic-of-generative-versus-discriminative-approaches-to-probabilistic-substrate_fig1_328165343 [accessed 19 Jun 2025])

(3) Neural style: Neural style transfer is a technique that uses neural networks to apply the style of one image to another. It works by defining a loss function that encourages the output image to match the content of one input image and the style of another input image. Neural style transfer has applications in fields such as digital art and image editing. (8)

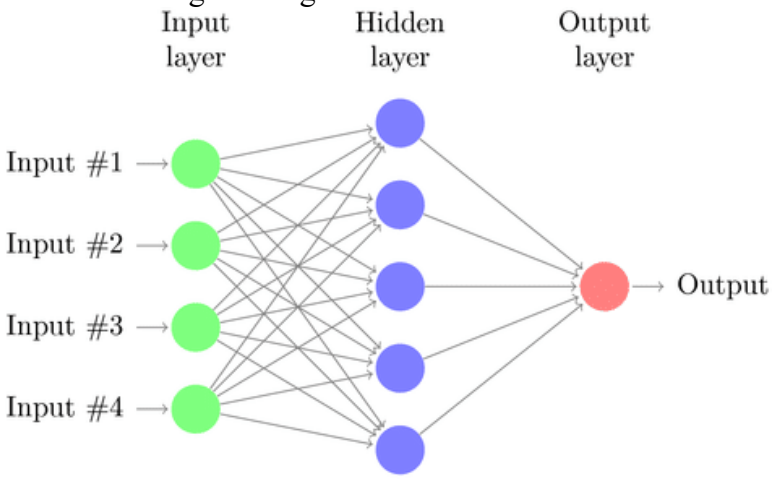

Fig.4. Neural Style (https://www.researchgate.net/figure/Neural-network-and-its-building-blocks-A-Schematic-of-a-NN-model-with-an-input-layer_fig2_366772564)

(4) Diffusion model: The diffusion model is a computational model of decision making that assumes that information accumulates over time until a decision threshold is reached. The model can be used to study how different factors, such as task difficulty or cognitive load, affect decision making. The diffusion model has applications in fields such as psychology and neuroscience. (9)

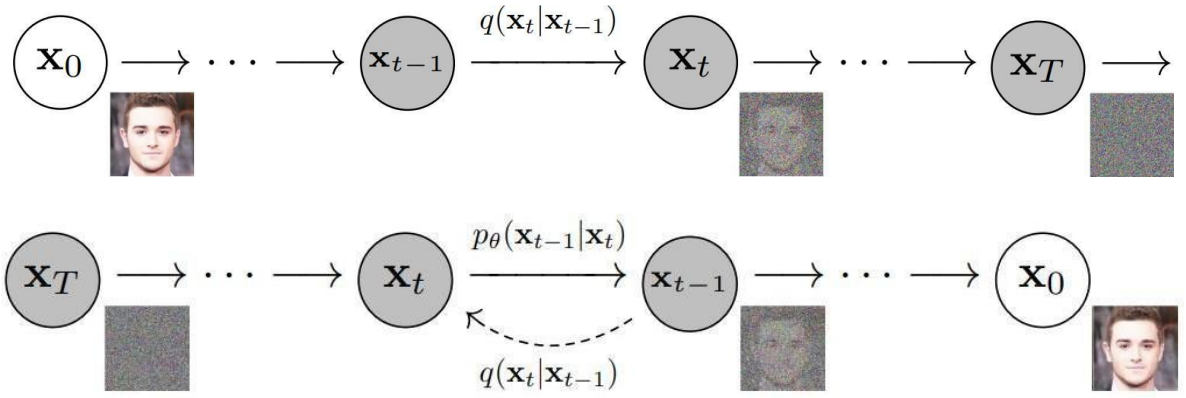

Fig. 5. Diffusion Model working (https://arxiv.org/abs/2006.11239)

Materials and Methods

This paper describes a method of understanding these different models through existing data over the internet. Analyzing how these images have been generated by different architects and students. Considering there are actually a huge number of companies and programs working on image generation but the three most famous ones are: Stable Diffusion, Midjourney and Dall-E and these three are the most widely used softwares that people have been using for their design processes. Even though these models are fairly similar to each other, there are still a massive difference between them in the manner they operate.

1. Stable diffusion

- Input – Both text and Image
- Output – Generates a combination of the input images and noise added by the model
- Model technology – Diffusion model

2. Dall -E

- Input – Text prompts
- Output – Generates Images that correspond to the input text description
- Model Technology – Deep Learning and generative modelling

3. Midjourney

- Input – It takes input through text and a GUI (graphical user interface)
- Output – Generates Images that are combination of user input and model's interpretation
- Model technology – Uses a combination of neural style and generative modeling

These three softwares although very powerful still only generate images which might look beautiful but still need an architect's hand if they are to be actually built. Especially the ones like Dall-E and Midjourney which are readily available to the public can give out stunning designs and concepts but a person can never be sure if its actually buildable or economically f feasible for their requirements. Additionally, these two do not accept image promts so its tough for the user to provide metrics like dimensions through precise cad drawings which are usually the deciding factor for a design to be

realistically constructed. This is the parameter where stable diffusion shines where you can create your own data base of certain required images to train the AI based on how you want it to work. Regarding these shortcoming of these publicly available platforms, this paper further goes into doing case studies of more architecture-specific softwares that have been worked upon in the recent years. Especially focusing on 4 major case studies.

(1) Finch 3d by Jesper Wallgren

A company called Finch 3d founded by Jesper Wallgren is working on creating a machine platform that can generate these alternate design options in a matter of seconds. The alterations that an architect takes hours or even days to do, the machine learning platform can carry out in mere seconds. They describe their work as "Finch works as an extension to already established CAD/BIM tools. To build it as an extension was a decision we took very early in the design of Finch.

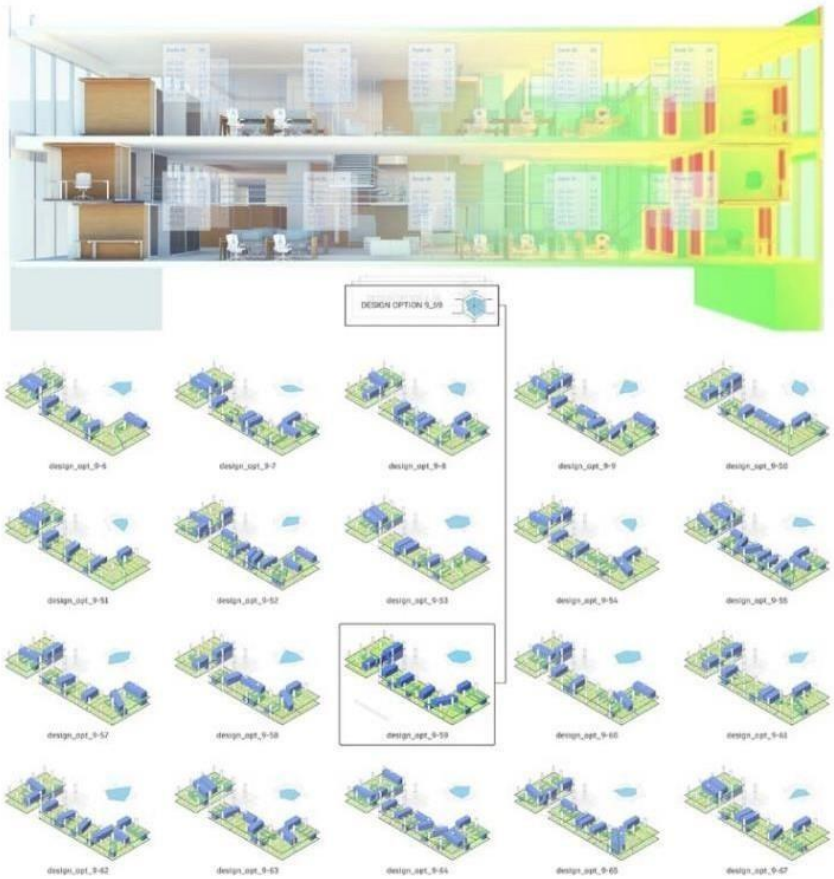

Fig.5. Generative design for the MaRS Autodesk Office Project (Source: www.autodesk.com)

We think it's important that architects can continue to design in the environment they're use to - Finch will just make it smarter." (10)
And even though they've described Finch as something that'll help an architect in the early phases of project, we can only wonder how strong these softwares will get in the coming future.

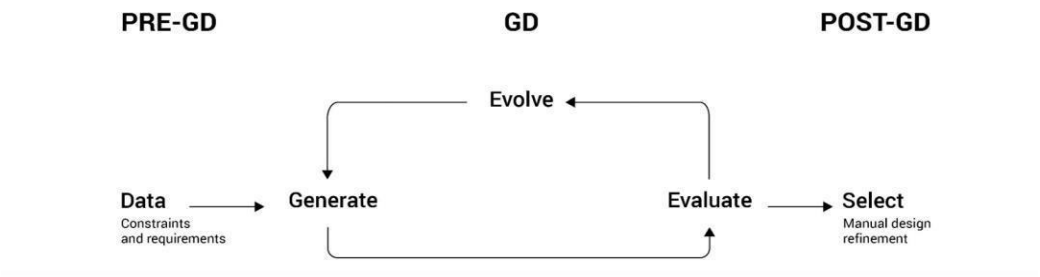

Fig.6. Generative design workflow (https://www.autodesk.com/autodesk-university/article/Generative-Design-Architectural-Space-Planning)

Designs can be altered in real time just by changing one aspect of the entire project. In this particular example, moving just a wall alters indoor spaces, massing, the placement of furniture, toilet, windows etc in real time. This is not done randomly but works on a calculated data set and works almost better than any human being to create the most optimal solution that can be provided.

Fig.7. Changing one aspect of the design leads to modulations (https://www.finch3d.com/)

Not just automated planning, AI can work with 3d volume massing as well. In this example, we see what the ai software that Finch is working on s capable of.
Here, massing is done real time where Finch 3d provides data like the gross floor

area, the percentages etc while you're working on your model (In this particular case, its Rhyno). Also, any changes done in the model are immediately updated. This saves tremendous amount of time.

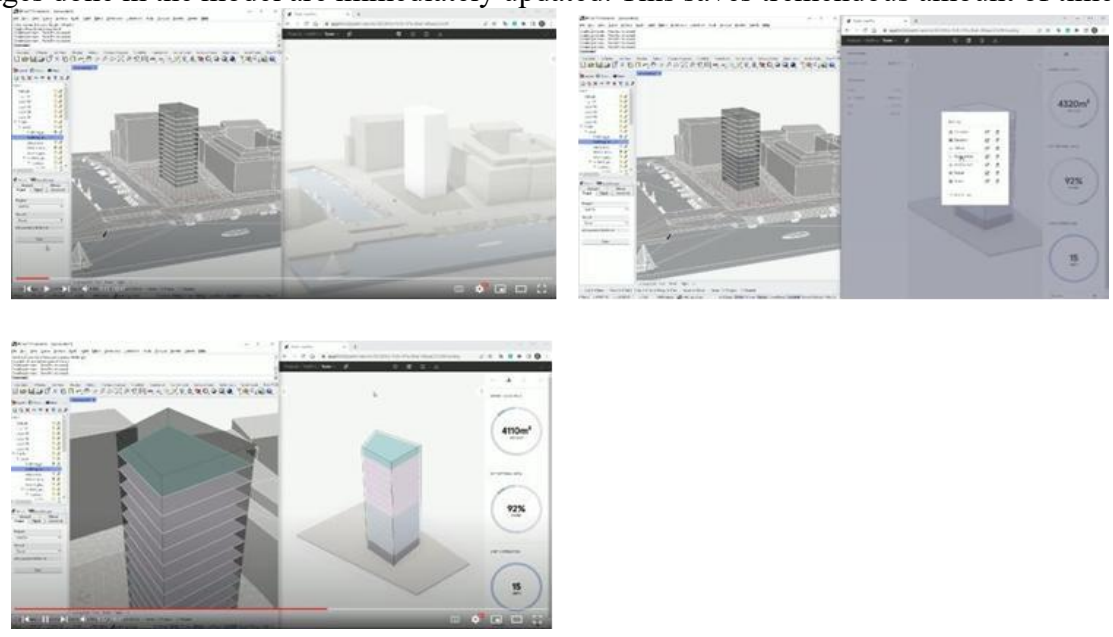

Fig.8. Real time updation of model and its parameters (https://www.finch3d.com/)

(2) ARCHITEChTURES

The second example is ARCHITEChTURES AI-Powered Building Design where not only a design model, but the site, and details are drafted very easily within a span of a few minutes. Drawing just a line gives you the plan of an entire building design which is the most optimal for the provided site settings.

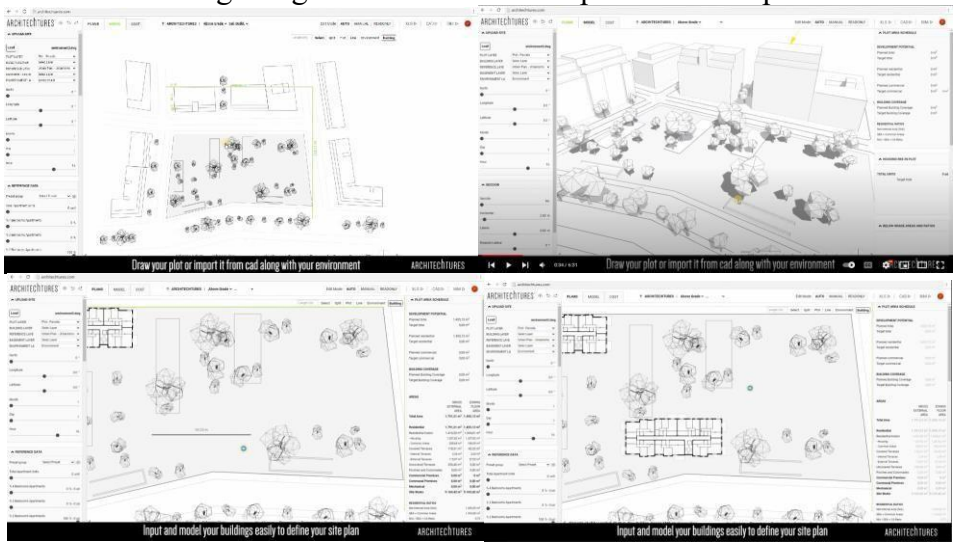

Fig.9. Only a line gives out the entire plan which can further be altered (https://architechtures.com/en)

This particular software not only provides real time planning and modelling, but also gives real time analysis of complex data like plot area, built up area, their costing depending on the material, terrace details, uncovered terrace areas, GEA+ common area, net internal area and so much more.
This data is all generated While we're working on the model.

Fig. 10. The internal planning is changed with just one click (https://architechtures.com/en)

Alternate designs are generated in mere seconds. Proving the best possible solution the minimum amount of area. Which is customizable depending on the site context.

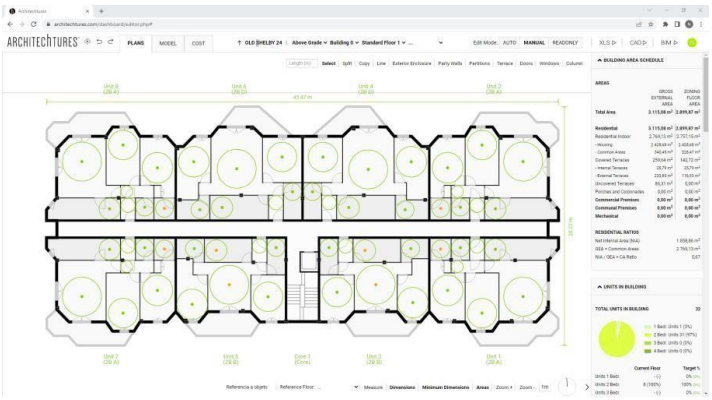

Fig. 11. With each modulation, date is updated on its own. Without drafting (https://architechtures.com/en)

(3) PlanFinder

PlanFinder is another AI model made for softwares like Rhino, Grasshopper and Revit which has 3 major features.

(a) Generate - Generate floor plans by simply giving the outer boundary and the desired rooms. In a few seconds, multiple options are generated.

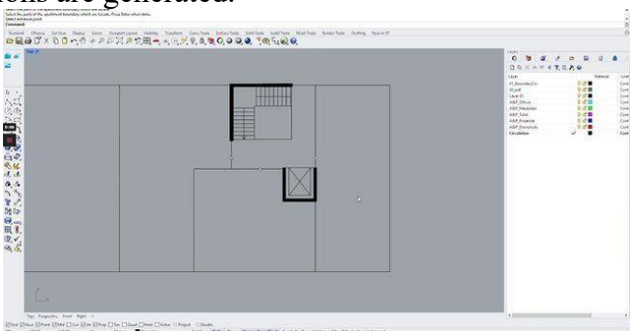

Fig.12. Base plan

(b) Fit - Quickly fit apartment floor plans and explore variations. Recycle existing designs and create your own floor plan library.

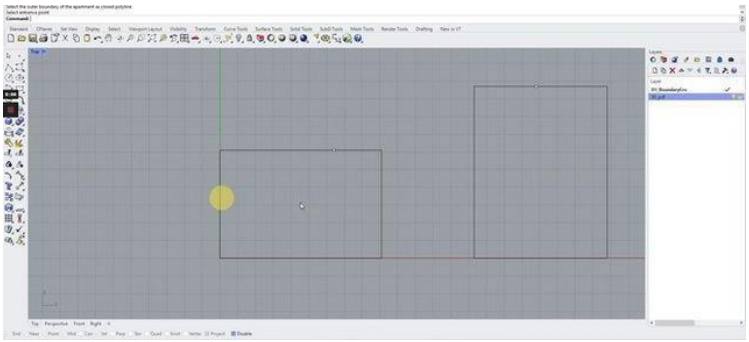

Fig.13. Drafting a simple rectangle

(c) Furnish - Furnish a plan in less than a second, and customize it to your needs.

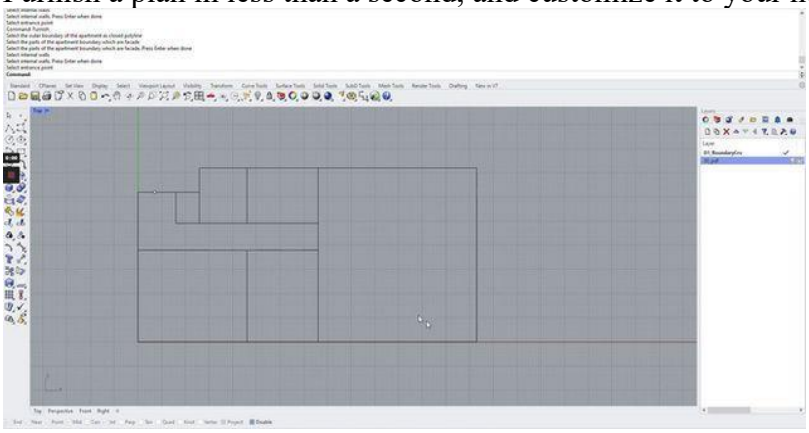

Fig.14. The rectangle is divided accordingly

(4) D5 Render

This AI software creates render, models, images, etc in real time. The example we see below has been created entirely using this particular software.

Fig.15. Sketch generated through AI

Usually, there were no clear objectives at the beginning of the project. Thus, after generating a large number of sketches, SUS made constant adjustments to see if there would be more possible design plans. During this process, an architect first drew a rough sketch and then gave AI some prompts to create many similar works.

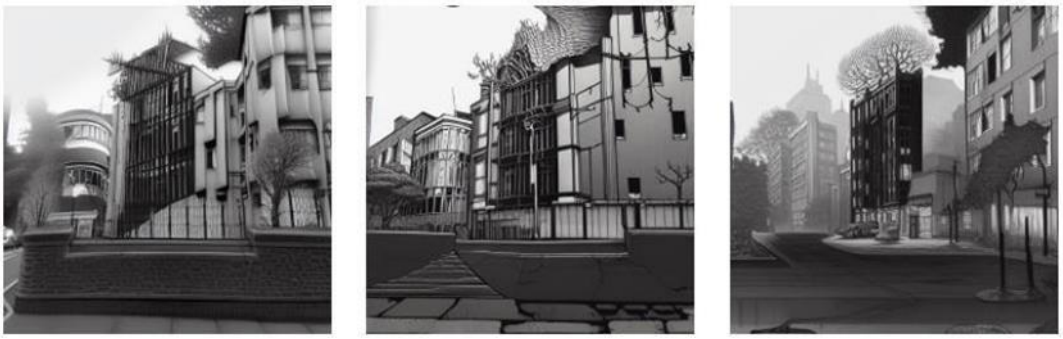

Fig.16. Adding promts to further develop the sketch (https://www.d5render.com/)

Yet not all of them were practicable. So the architect had to choose some feasible sketches and gave AI more prompts to optimize their light and shadow. Meanwhile, tags of master architects will be added as a reference for the architectural style. There was trial and error at this stage before the designer could

confirm the architectural volume including concave or convex, curved or straight lines, and so on.

Fig.17. Adding architects' names for the AI to reference the design from (https://www.d5render.com/)

Move on to fine-tune the prompt and try different CFG Scale* and Denoising Strength*. This would produce images of various design styles. The architect chose an appropriate one from them and made inpainting on some important or unsatisfactory details. For example, the roof of Rain Moment Street was inpainted to have a look of a hollow net- like form resembling dragon scales. The CFG scale adjusts how much the image looks closer to the prompt and/ or input image.
Denoising strength controls how many changes it will make compared with the original image.

Fig.18. Design Render-1 (https://www.d5render.com/)

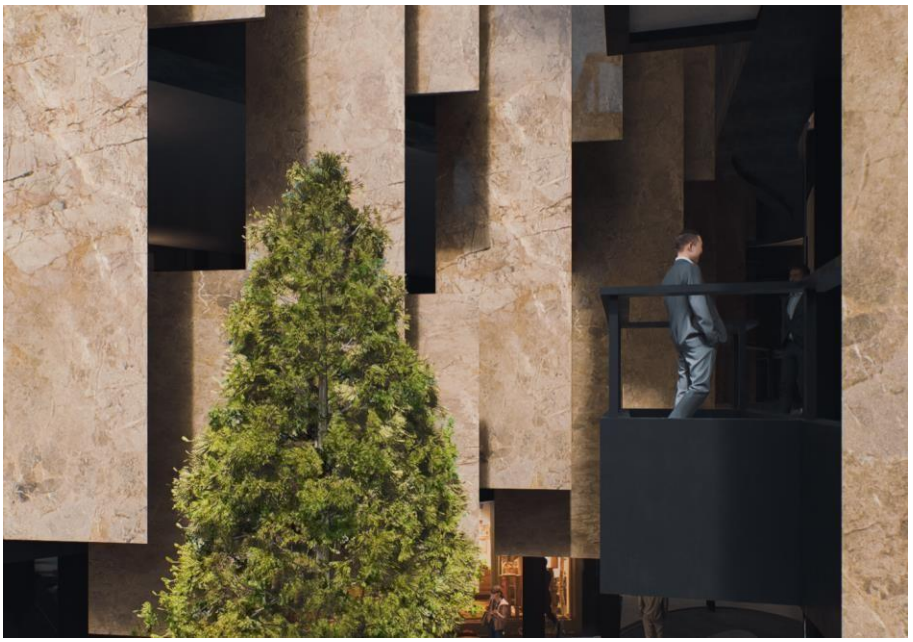

Fig.19. Render -2 (https://www.d5render.com/)

For the past few years, we've seen massive technological advancements. And catching up to these new technologies are something that every student needs. Especially in the field as competitive as architecture. Moreover, looking at the debates that have been conducted regarding whether AI is ethical or not, we need to first understand what it is before forming any opinions and this study tries to provide a holistic approach to it. Initially AI was expected to do the mundane repetitive tasks so that people could have time to work on their creative sides but it has been observed that it has attacked the creative fields the most. Especially after the introduction of platforms like Dall-e, Midjourney etc.

A questionnaire was prepared to understand people's perception on AI. And the data base consists of both working professionals and students of both architectural and non-architectural background. The total number of responses received were 130. Amongst these respondents, more than half were from architectural background. While 1/4th is from computer science and the rest belongs to others.

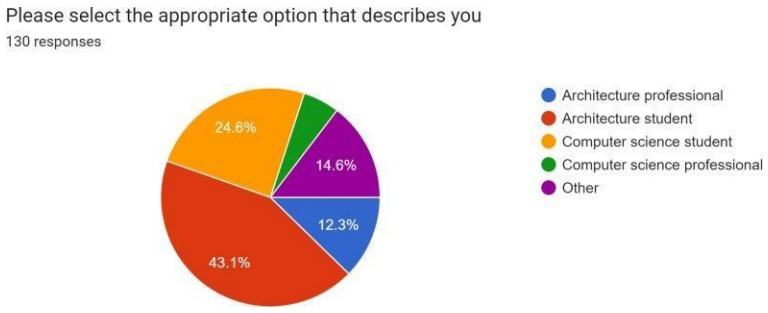

Fig.20. Understanding the respondents

Findings

Almost everyone knows what AI is, in the survey, it was found that either they know it, or they're not sure.

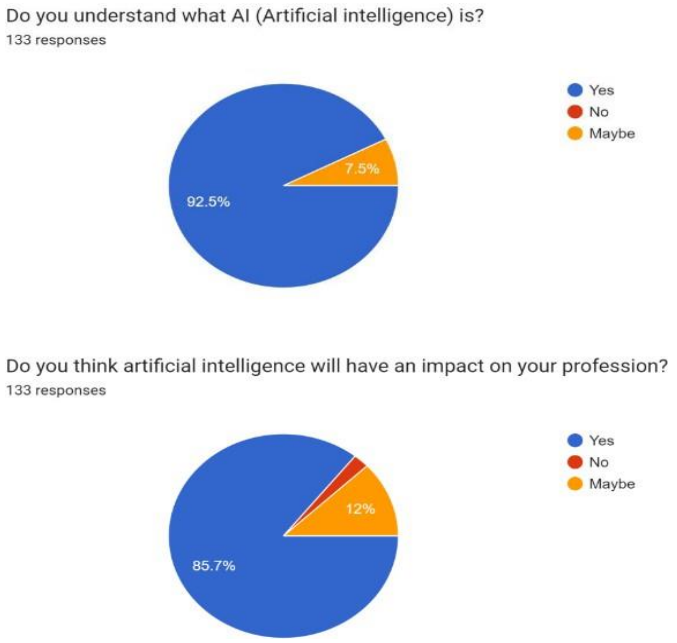

Fig.21. If the respondents understand AI and if it would affect their profession

Almost everyone, be it a student or a professional, they all think that AI would affect their jobs. And amongst the 11% than were not sure, most of them were from non-architectural background and the one who selected NO as an answer were more than 30 years of age.

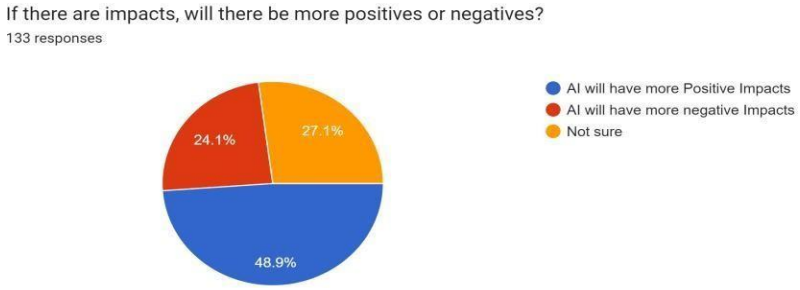

Fig.22. Perception of the affects AI can have

When it came to impacts half of the people think it would have a positive impact while a quarter think it wont, and a quarter are not sure.

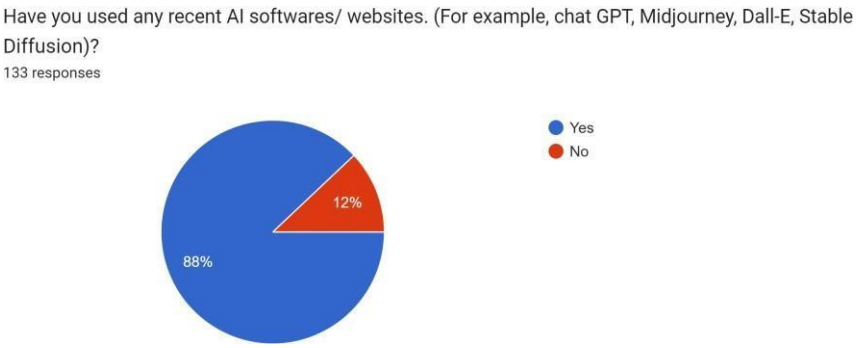

Fig.23. Have the respondents used AI tools yet

Most of the people are aware of how AI works and have used most of the famous AI technologies. The ones who haven't, are again more than 30 years of age or are from non- architectural background.
More than 90% of people think that the use of AI will significantly increase in the next 5-10 years. There isn't anyone who doesn't think the opposite and the ones who are not sure are again from non-architectural background. Even though people think the impact AI can have is positive, they still think that AI might have more disadvantages than advantages.

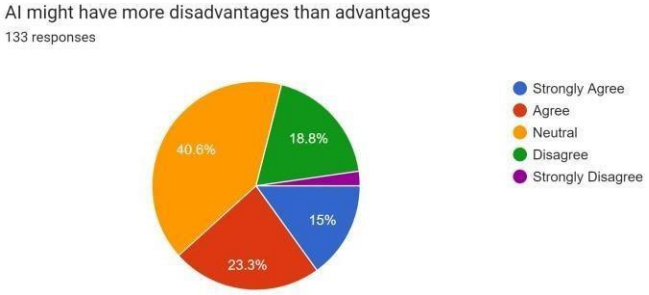

Fig.24. Inquiring their understanding of having advantages

With a total of 40%. While 40% are indifferent, almost 20% disagree When it comes to regulation of AI more than 70% of people think that AI should be regulated. Most of the people think that creativity will have a negative impact More than 70% people think that architects are anyways not consulted for smaller projects, and AI will have a larger impact on us.

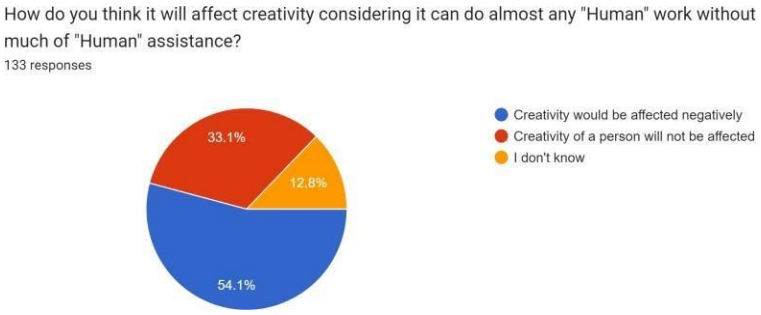

Fig.25. Affect on creativity

Also, almost 80% of people agree that it will be the young architects that are starting their journey of architecture that will be affected the most.

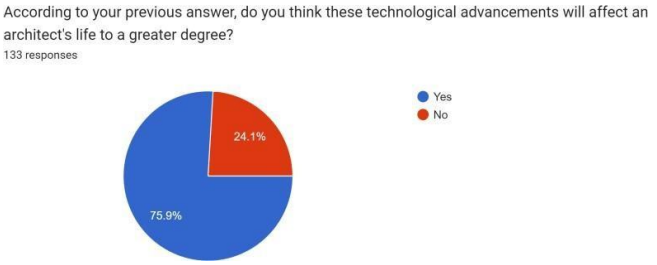

Fig.26. Affect on architecture as a profession

Half of the people think that students and architects should be concerned for their jobs in the future.
People are almost aware of what AI is and they all agree that AI WILL affect their jobs. And the impact would be more negative than positive. Especially for architects. When it comes to architecture, its usually the older or established architects that think that AI would not affect their jobs. While the sentiment is not the same for the younger students or even younger working professionals. As a job, architecture even now is considered an elite job in India where common people don't approach an architect for the projects they want built and now that most of the work an architect can do is now possible with AI, that too within a few seconds, it IS something that people should be concerned about.
People have used these AI tools and are aware that the use will increase very significantly in the next 5-10 years. Considering how it's growing, it should be regulated too. People's responses-

- "Computational design is one of the futuristic phase of architecture which will definitely grow with slow phase. I believe technology is the future and AI have a great impact on architecture professionals."
- "Learn ai and become better than the ones who haven't learned it ezpz.
- "I believe AI will be a very helpful tool to ease monotonous tasks in an architect's daily work, and integrating it with the curriculum will make students use it for their own good rather than focusing on its bad aspects."
- "I'm generally positive with AI, but it has to be regulated. As a technology itself, it can have many applications. The only problem is HOW people use it, and how it is trained, without breaking the code of ethics. It can affect the creativity of future generations both positively and negatively; negatively being people can make "shortcuts" without much integrity for the craft, and positively being creatives with much passion can use AI to assist with various tasks so that they can focus more on expounding, exploring, and innovating"
- "People stop using any new apps as fast as they start using it. Those who understand the value of plagiarism will eventually stop using"
- "AI platforms like Chatgpt. What we now need to focus on is the solution to negative uses of AI, that is, AI detecting softwares. Might not help in architecture, but again, AI can also make plans but not customized plans. And again, the question is, do we trust AI with our work? We did a little experiment with one of our master's assignments. The assignment produced by AI was not even close to being correct. Infact, it confused itself to a level that our professor graded it 68%, near to fail as per our 61% benchmark. However, the same assignment done by a student was graded 88% with the remarks "excellent work". So eventually we'd all realize that it is not a trustable source for our intelligence."

- "AI would deeply effect the profession especially to the young professionals engaged in the small scale projects.
- "AI can help an architect in many ways, but AI wont be able to take over an architect."
- "Ai will not just affect architecture profession but all professions."

- "Try architectures ai and other ai like versa ai etc which have plugins in softwares such as revit rhino sketchup"
- "I am a computer science student and AI will enhance the skills of the architect using some advance tool they will analyze more and should be more creative and advance with their work"

Conclusion

"A.I. won't replace architect's jobs, rather it'll be people who know how to use A.I. will"

It was initially thought that A.I. would take over the jobs that are repetitive and troublesome but the first wave of the new age A.I. revolution has been observed to affect the creative fields the most. A.I. is an

immensely powerful tool with tremendous potential for utility. However, its remarkable speed and self-learning capabilities also bring significant threats. Consequently, individuals should exhibit concern, but instead of perceiving it solely as a detriment to their professions, they ought to embrace it and harness its advantages. It is important to recognize that AI will not replace jobs; rather, it will be the individuals who possess the knowledge of how to leverage AI effectively. Hence, it is important to incorporate AI education into school and university curriculum, particularly for professionals and students, to ensure they stay abreast of these advancements. AI as a technology will affect the new budding architects the most, hence it should be mandatory to teach AI to architecture students in their initial years so that they can fully understand and get accustomed to the working of these softwares. Architects, especially the new ones should leverage these technological advancements to their advantage but also understand the working of it so that they can make a smart and moral decision when it comes to the use of AI. Especially considering the data it uses is not yet claimed as copyrighted material. Overall, AI will have both positive and negative impacts depending on how an architect perceives it and in order to make a proper prediction, a person should first learn about the topic and come to an informed conclusion. Its just a tool, similar to the CAD or BIM softwares that we use in our daily lives, and can be treated as an extension to these. The fact that in the coming years AI would be just another extension to the apps that people use on their digital devices, it is highly important for an architect to get used to this technology if they have to stay up to date.

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