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AI in Architecture and Urban Design and Planning: Case studies on three AI applications

Sajjad Naseri *

Department of Civil, Chemical, Environmental, and Materials Engineering – DICAM, Alma Mater Studiorum - Università di Bologna, Italy.

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Abstract

The use of artificial intelligence (AI) in the built environment is changing traditional methods by improving sustainability, efficiency, and innovation. This study examines the positive and negative aspects of adopting three AI technologies to improve design and planning processes: PlanFinder, TestFit, and Luma. PlanFinder's ability to generate multiple options for design in just a couple of seconds benefits both professional and beginner designers which is speeding up the creation of building designs. TestFit simplifies urban planning by swiftly generating site designs that consider cost and zoning which is allowing urban planners and real estate developers to make informed decisions. Luma enables the creation of realistic 3D animations from a simple models to enhance project visualization and presentation quality.

While these technologies provide major benefits to save time, lowering down costs, and allowing for greater experimentation, they also have drawbacks. These include dependency on accurate data, limited modification choices and potential compatibility issues with complex projects. Furthermore, the use of AI brings questions regarding the ethical implications of technology and its impact on the labor force. This study offers a helpful perspective for educators, architects, urban planners and designers considering using AI into their work.

Keywords: Architecture; Artificial Intelligence; Sustainability; Urban Design; Urban Planning

1. Introduction

Our approach to design is changing because of artificial intelligence (AI). Especially in the field of architecture. The use of AI in architecture is developing quickly and it is increasingly influencing the planning and design of cities and structures. AI gives architects strong tools that enable them address difficult challenges produce creative solutions and make choices more quickly. AI is being used in a wide range of fields, including energy efficiency, environmental sustainability, interior design, and architecture.

The integration of AI into architectural processes is already influencing the way spaces are organized and shaped. For instance, AI can analyze large datasets to help architects optimize space layouts in a way that would be very difficult for humans. Algorithms powered by AI are able to evaluate physical connections and suggest layouts according to particular standards like user requirements and energy efficiency (1).

Another significant area where this technology has impact is in generative design which tools like MidJourney and other AI based image generators are already being used to create new forms of structures that were not exist before. generative design tools can assist in the creative process by suggesting novel architectural forms. These tools use

* Corresponding author: Sajjad Naseri

machine learning models to generate hundreds of design alternatives quickly (2). This enables architects to explore various design options, refine their concepts, and make decisions more efficiently.

AI's influence on sustainability in architecture is another major factor driving its adoption. AI can optimize energy efficiency throughout a building's lifecycle, from its initial design to its operation and eventual demolition. AI is being used to reduce energy consumption in buildings by predicting energy demands, optimizing heating, ventilation, and air conditioning (HVAC) systems, and improving overall energy performance (3).

Furthermore, AI is increasingly being included into architectural courses of study. Students have developed skill that will be important to the future of the industry due to the incorporation of AI into architectural programs. Students may create more effectively to experiment new concepts and get involved with sustainability with these tools as soon as possible. Additionally, they provide multidisciplinary learning opportunities where students may collaborate with data scientists as well as engineers and urban planners to produce ideas that are not only visually beautiful but also highly advanced and sustainable (4)

Although AI has many advantages, there are disadvantages as well that must be considered. One of the most serious obstacles is the possibility of AI replacing human workers. According to some of the experts, AI should be considered as a tool that enhances human creativity rather than replacing professionals. To make sure AI is used correctly in ways that improve human understanding is also difficult. AI techniques must be transparent in order to avoid biases and ensure inclusive designs (5).

AI is also becoming more important in urban design as buildings and cities become smarter. Generative urban design technologies use AI to analyze urban trends and create new city designs. These techniques can help urban planners improve environmental sustainability which is a real challenge nowadays because of climate change, traffic flow and space use. AI may help decision-making by modeling various situations and projecting the outcomes of possible design plans (6). It is particularly helpful when urban populations are increasing and traditional design methods are unable to stay current with the needs of modern cities. Large volumes of environmental data may also be included into the design process to ensure that cities are not only livable but also sufficiently sustainable and climate change adaptable.

2. Literature Review

In recent years, AI has become known as a major source of change in architecture and urban design. As AI technologies advance, architects and designers gain powerful new tools to boost efficiency, creativity, and sustainability. AI is being utilized in architecture to help with design processes, automate tasks, and find new solutions to complicated challenges.

One of the main fields where AI has had a big impact in is architectural design. Traditional architectural design procedures frequently include long design stages. It needed designers to manually calculate and organize spatial features. It can automate these tasks by developing algorithms that generate appropriate result based on established parameters such as utility as well as safety and aesthetic preferences. (1) investigated the use of AI in architectural urban planning, focusing on how AI can improve design efficiency and assist architects in making more informed decisions. AI's capacity to efficiently process massive volumes of data enables designers to explore a broader range of design alternatives and discover ideas that would not have been considered using traditional approaches.

AI-powered tools are also changing the role of architects. (7) examined the use of advanced AI technologies like ChatGPT in architectural design and engineering. They pointed out that these technologies are intended to help architects by suggesting design solutions, automating repetitive tasks, and providing insights based on previous projects. As these technologies grow, they will be able to provide architects with more innovative ideas and solutions targeted to individual project needs. The potential to include AI into architectural processes is changing the way architects approach design difficulties which is allowing them to focus on more advanced making decisions while AI deals with more regular tasks.

Generative design is another significant way that AI is being used in architecture. Based on specified criteria, generative design employs its algorithms to investigate an extensive range of design options which enables designers to produce complex and creative shapes that was not before in the traditional methods. The potential of powered by AI generative tools like MidJourney which lets architects to create new shapes, was highlighted by (2)

AI may also enhance the sustainability of building design. (4) explored how AI may improve resource efficiency, lower energy usage, and optimize design processes to support sustainable architecture. AI can help architects create designs

that are more energy efficient by analyzing building performance and recommending changes that improve it. Furthermore, It can support the integration of sustainable materials and technologies into architectural projects.

This technology is being used to improve architectural education and training in addition to generative design. AI tools are being incorporated into architecture education programs as they become more accessible. Students have been taught about sustainable design method using AI tools that let them experiment with various environmental friendly material techniques. It may also help students in understanding the complexity of contemporary architectural problems, like building performance and urban design (8).

AI's ability to improve creativity highlights its significance in architecture education. By allowing students to experiment with new concepts and design possibilities, artificial intelligence is encouraging creativity in the teaching of architecture and interior design. Students may rapidly create and test many design ideas with AI technologies which encourages the development of their creative thinking (4).

While it has numerous advantages for architecture, it may have create some problems. The moral consequences of using AI to architectural techniques are one of the main issues. Concerns including algorithmic bias, data privacy, and the possible loss of human labor are important issues that must be addressed as AI becomes increasingly common. To make sure that it is using properly and its advantages are shared equitably throughout society, architects and policymakers must collaborate with each other (5).

The future of human work force in architecture is also put into doubt by it's involvement in architectural design. Concern that this technology may replace human is rising as they get more powerful. Many experts argue that AI should be viewed as a tool to improve it rather than taking the place of human creativity. AI can help architects overcome creative difficulties and explore new design ideas (9). AI can help architects focus on more complex design problems by automating repetitive activities and offering innovative ideas.

AI is also being used to optimize building performance throughout the entire lifecycle of a building. AI algorithms can analyze energy usage patterns and recommend strategies to optimize energy efficiency, such as adjusting HVAC systems, improving insulation, or selecting energy-efficient materials (3).

AI has a lot of possibilities for urban design as well. (10) talked about how AI may be applied to create city design to enhance the flow of traffic and improve public transportation systems efficiency. To help identify locations that need renovation including those with high pollution levels or a lack of green space it can additionally look at street-level photos.

3. Purpose of Research

The purpose of this study is to find out how artificial intelligence (AI) techniques are changing the field of architecture and urban design. Because of advancement in technology artificial intelligence is being utilized to simplify complicated design processes which is improving efficiency and provide innovative approaches to sustainability. This study looks to investigate how powered by artificial intelligence software like PlanFinder, TestFit and Luma help architects and urban planner and designers in their everyday job. The research also aims to explore the benefits and drawbacks of using AI in these fields.

This study specifically looks at how AI technologies could help with building design as well as urban space planning, and design presentation advancements. It analyzes how these technologies may save money and time and allow for creative experimentation while still providing practical functionality.

In addition to these benefits, this study analyzes the limitations and risks of AI in architecture and urban planning. Ethical considerations like employment displacement and the need for reliable data, must be addressed. By examining these elements, this study hopes to give a balanced perspective on how AI might be integrated into design procedures to supplement human knowledge while managing its difficulties.

4. Research Method

Three AI tools, namely PlanFinder, TestFit, and Luma were evaluated in this study using a practical and analytical methodology. Real case studies designed in these software for this study. The usefulness, usability, and efficiency of

each tool in resolving certain design and planning issues have been evaluated. These technologies were utilized for tasks such as making visual animations, developing urban areas, and designing building plans in order to collect data.

Table 1 shows comparison of the features of the examined AI tools, highlighting their input requirements, output formats, and time for results.

Table 1 Key Features of Evaluated AI Tools

Feature	PlanFinder	TestFit	Luma
Input Requirements	Space size, room details	Site boundaries, zoning	3D models, basic sketches
Output Format	Multiple layout options	2D/3D site plans	Realistic animations
Time for Results	~20-25 seconds	~30 seconds	~10-30 minutes

Basic input data, including site borders or 3D models, were used to start the testing procedure. Real time performance observations were made of each instrument, evaluating how rapidly and precisely it generated results. For example, TestFit was used to construct a site plan based on zoning restrictions and PlanFinder's ability to generate several plan possibilities was evaluated by entering room parameters. Luma's ability to create an animation that represent ideas for urban and architectural designers was tested.

To fully understand the broader effects of AI in design, data have been compared with secondary data from the body of existing research in addition to testing. During the testing phase, issues such compliance with regional standards as well as the need for data provided by user and restricted flexibility were identified.

A comprehensive evaluation of AI tools' performance in daily life was made possible by this a combination approach, which also revealed the limitations and usefulness of these tools. The purpose of these studies is to provide guidance to architects and urban planners on how to successfully integrate AI into the way they work.

5. How AI Works

Artificial intelligence gathers data by using computers and mathematics. This technology attempts to mimic how people learn and make decisions. Algorithms are collections of rules that enable AI to interpret data and make a decision. These algorithms search for connections and patterns in data. AI can understand and make decisions or even produce new objects using these patterns (11).

Machine learning is at the core of AI. When computers learn from examples rather than precise instructions, this is known as machine learning. A lot of data is used to train AI models in order to accomplish this. This training teaches AI to identify specific objects. For example, if it views enough images of cats, it will learn to identify a cat in a new image. Neural networks are a key component of this process. Like the human brain, these networks are made up of layers of "neurons" that cooperate to process information. The data is further reduced by each layer, which makes it easier to identify patterns.

AI can also be explainable. Explainable AI, or XAI, aims to make the workings of AI clear to humans. This is important for trust because people want to understand why AI makes certain decisions. XAI tools give insights into how AI reaches its answers which is helping to build confidence in AI systems (12).

As shown in Figure 1, AI operates through a series of algorithms and data processing steps to make predictions and decisions.

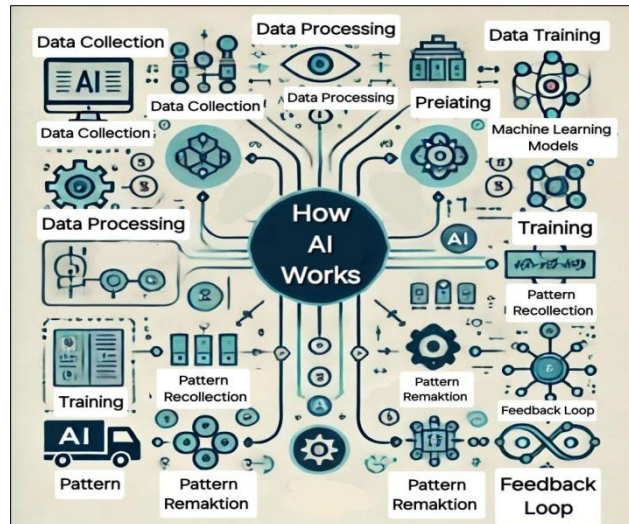


Figure 1 Illustrating how AI functions

AI's methods are not perfect. It relies heavily on data, and poor data can lead to poor decisions. But with careful training, it can perform complex tasks and improve over time. As AI advances, it becomes a more powerful tool for solving problems and creating solutions across many fields, from medicine to design (13).

6. AI Platforms for Architectural and Urban Design

6.1. PlanFinder AI

6.1.1. Introduction

Normally, designing a layout for a building or space takes time and requires a lot of adjustments. Architects and planners usually spend hours or days to find a design that's functional and visually pleasing. But PlanFinder is a tool that uses AI to make this process faster, simpler, and more efficient. It's accessible for people with limited design experience and valuable for professionals. You just input some basic details, and it generates a plan that you can work with right away.

6.1.2. How PlanFinder Works

To begin using PlanFinder, input some basic information about your project. You only need to specify the size of the area, the number of rooms, and any special requirements. We tested PlanFinder myself, and all we had to do was draw the external walls and enter them into the application. We were amazed by how quickly it worked. The initial plan took only 20 seconds to generate, followed by 25 seconds for subsequent options. It developed four complete plans in 25 seconds and finished the procedure for us. It's a basic method that yields effective outcomes. As shown in Figure 2, we began by drawing the exterior walls to set the foundation for the layout.

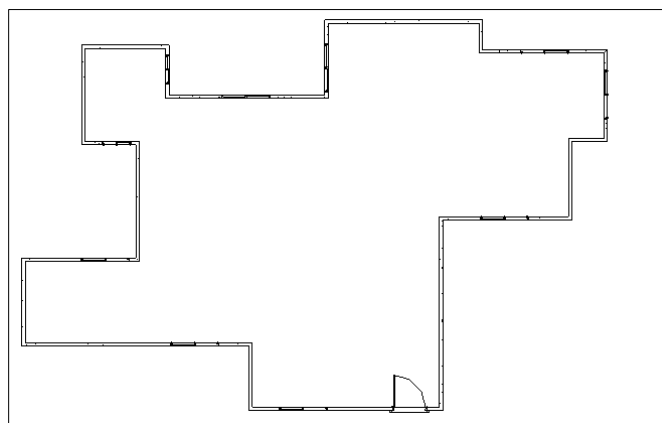


Figure 2 Author's drawing of the exterior walls for layout generation in PlanFinder

Once you've entered these details, the AI in PlanFinder takes over. The tool starts to build a layout based on the information you gave it. It organizes the space in a way that makes sense for your specifications, such as placing the rooms logically and ensuring everything is in proportion. The AI arranges rooms so they connect naturally. For example, if you're designing a home, it might position the kitchen close to the dining area for convenience or ensure that bedrooms are placed in quieter areas away from main entrances. It quickly builds a plan that could take hours to design manually.

Figure 3 Shows PlanFinder generated two different plans options based on my specifications



Figure 3 Plans generated by PlanFinder based on initial input specifications (14).

It also considers other layout factors, like room flow and functionality, making sure the final plan isn't just visually appealing but also practical. This is a key feature because layout planning isn't only about making things look good; it's also about creating spaces that are useful and comfortable. PlanFinder can do this without any additional input once you've provided the initial details.

6.1.3. What Makes PlanFinder Beneficial

One of PlanFinder's greatest benefits is its speed. Building layouts typically need a great deal of trial and error. Until they discover the ideal solution, designers frequently spend hours rearranging rooms, modifying walls, and trying out other concepts. Much of this difficult task is done by the AI with PlanFinder. It quickly selects the finest arrangements after trying out variety of them. This implies that you can have a finished layout in a matter of seconds rather than hours or days working on a single concept. We found it remarkable and time-saving to examine four layout alternatives in only 25 seconds.

Additionally, PlanFinder continuously improves its design in response to your first input. It may keep creating different kinds if you desire additional alternatives, providing you with a larger selection of options quickly. Using traditional design approaches would take considerably longer than this simple process which lets you quickly experiment with alternative designs. This capability of seeing several layouts in a matter of seconds may be quite helpful for larger projects, helping you to test out more concepts without wasting time.

6.1.4. Who Can Benefit

This AI is helpful to users with different level of design knowledge is one of the things that makes it unique. You might not know how to design a professional plan if you are new to design. It can assist you by producing an excellent plan without requiring design knowledge. Simply enter the necessary data and the program will take care of the rest. Because of this, people with different level of knowledge who may not have a design experience can use it.

But PlanFinder isn't just for beginners. It's also a powerful tool for professional designers who want to speed up the initial stages of a project. Experienced architects and planners can use PlanFinder to create quick layouts and test ideas without spending hours on the basics.

6.1.5. Customization Options

PlanFinder's customization choices are one of its many features. You are not restricted to what the AI creates once it has generated a layout. You have the ability to modify the layout. You have the ability to alter a room's location if you think a room needs to be more open.

This modification is crucial because it enables designers to modify each plan to satisfy certain specifications. Every project is different, even though the AI does a fantastic job at producing layouts that are both useful and visually beautiful. Customization involves altering PlanFinder's output to meet your unique requirements. Designers are able to customize the layout to best fit their project because to this valuable combination of automation and adaptation.

6.1.6. Impact on the Design Industry

There is more to PlanFinder than merely expediting the layout creation process. By making expert layout planning more accessible, it is changing the way that design is done. Traditionally, skill and expertise are needed to create a decent layout. To obtain a high-quality plan, many individuals would need to pay an architect or designer, but PlanFinder gives everyone the ability to generate a layout that looks professional. For those who might not have previously had access to design services, this creates opportunity.

For professional designers, PlanFinder offers a creative way to work more efficiently. By handling the repeated changing of layout generation, it gives them their time for the design elements that need creativity and experience. Instead of spending hours adjusting the layout, they may let PlanFinder handle the basics and then concentrate on enhancing and customizing it.

6.1.7. Disadvantages

One of PlanFinder's main drawbacks is the need for exact axis alignment while building the external walls. If the walls or other crucial elements are not precisely aligned, it could not offer designs. This limitation could irritate users who are not familiar with technical drawings. An additional stage in the setup procedure is added when the tool is unable to finish the layout due to even minor misalignment.

While it generates functional layouts quickly, the level of customization is sometimes limited. For example, it doesn't always allow for intricate design details or specific style preferences. Users may need to adjust the generated plans significantly to meet specific design standards which is adding time to the process.

Its emphasis on countries mostly located in Europe is another drawback. This might be an issue for customers in the US or other non-European countries because building codes, architectural requirements, and space planning standards can differ greatly. The AI-generated plans could need to be further modified to satisfy local standards if they follow European principles rather than American laws.

6.2. TestFit

6.2.1. Introduction

TestFit AI is a tool made to help urban designer and planners to design a community development plan quickly. It is especially useful for creating site plans for apartments, retail areas, and other types of buildings. Instead of spending a lot of time drawing and testing layouts by hand, it lets you make them in just a few minutes. It helps you figure out if your project will work on a piece of land while also keeping track of important details like costs and space.

This tool is easy to use and makes the design process faster and simpler. You do not need to be professional to be able to use it. It is designed to help both professionals and beginners get started with designing easily.

6.2.2. How TestFit AI Works

The first step is providing the program with some basic project details. You must first draw the site's boundaries. This lets the software know where to put your buildings and rules like zoning regulations or the amount of parking space required can also be added into software.

As shown in Fig 4, we simply identified the site boundaries and wanted it to design residential buildings in this specified site.

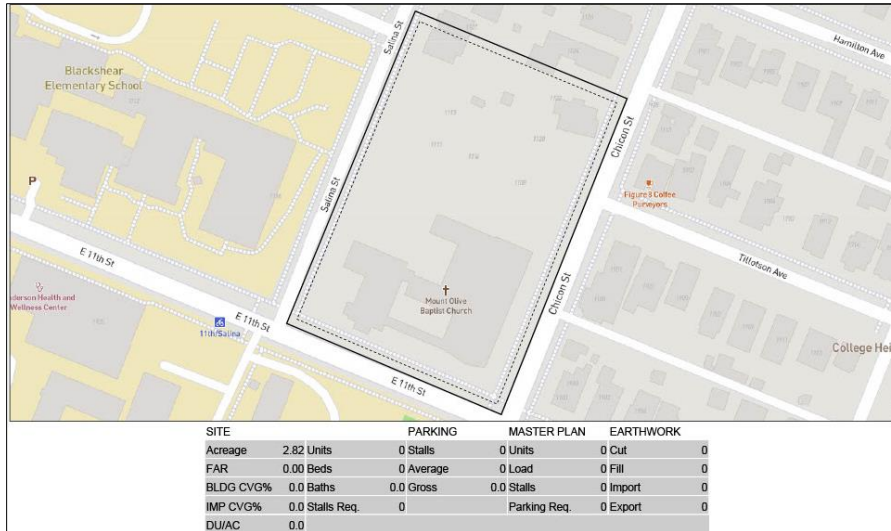


Figure 3 The site boundaries identified by the author

It starts working as soon as you enter this data. It evaluates the specifics and provides a plan that works with the land you have. If you are creating an apartment building, for instance, it will show you how much parking is required, where the units can go, and even how much room is left over for walkways or green spaces. Following figure 4, figure 5 shows the designed site by this software with some important data, such as number of units, beds, required parking spaces, and other data.

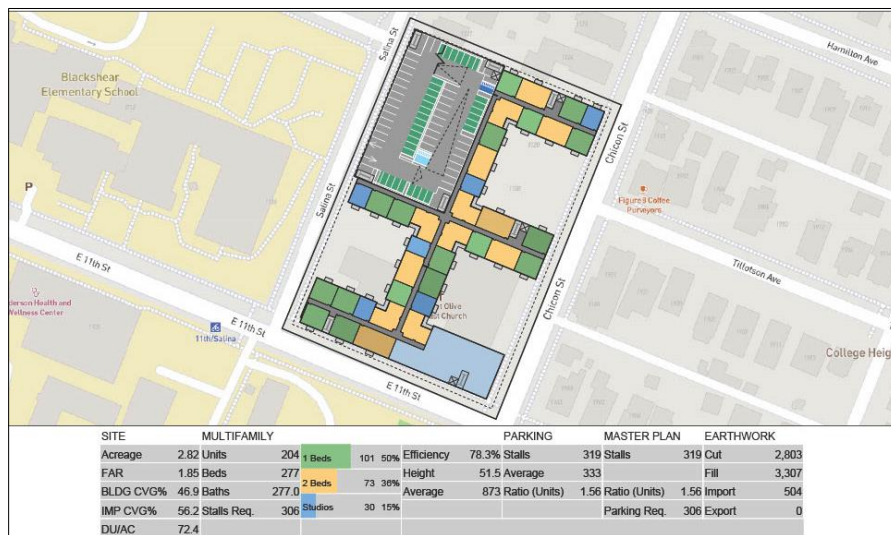


Figure 4 The designed site by TestFit Ai. Source: (15)

This process takes just a few seconds. Instead of spending hours or even days on sketches and measurements. It gives you a clear and detailed plan right away. You can try different options by changing the input details and instantly see how those changes affect the layout.

Interestingly, it can generate a 3D model for you and you can have and see it in this software or export a SKP format to use it in SketchUp as shown in figure 6.



Figure 5 3D Model generated by TestFit. Source: (15)

6.2.3. Benefits of TestFit AI

The speed of this software is one of its greatest benefits. Creating a site plan from the ground can be time consuming and difficult.

Saving money is an additional advantage. It supports you in preventing resource waste by displaying the most effective use of available space. To add more, it can calculate expenses and provide you with a more accurate estimate of the expenses of your project.

It is also extremely flexible. It can be used to a variety of building types, including offices, retail malls, towers, residential, etc. If necessary, you can modify the requirements or regulations, and the software will adapt the design accordingly which is making it simple to try out numerous ideas and select the most suitable one for your site.

Teams working on real estate projects may find the tool particularly useful. The design provides it clear to everyone how the building will seem and function. It makes it easy to communicate between engineers, clients, and other experts.

It is designed to be user-friendly. You don't have to know how to use computer design software. The user interface is easy to understand and use. All you need to do is add the project data and sketch the site's boundaries.

It is not an issue if you want to do something different or make a mistake. Whenever you want, you can go back and modify the information. You may continue exploring without having to start over because the tool will update the design quickly.

The software also tells you more about the design information. For example, it can tell you how many apartments can fit in the building and even how many bedrooms can fit in an apartment or how much parking space is required.

It also is a good tool for calculating the cos of a building to see if it worth to build or not, so real estate developers can also benefit greatly from this. They may rapidly determine the cost and viability of their plans by using this tool. Urban planners and designers who wish to ensure that their plans are feasible and compliant with zoning regulations can also find it useful.

It can be used by urban planners to create better neighborhoods as mentioned before. They can test different design ideas for new parks, streets, or buildings to see how they work together.

6.2.4. Limitations of TestFit AI

Despite being a strong tool, it has some drawbacks. The program may not be able to handle extremely complicated designs and performs best with simple layouts. To improve the design of a very complex project, you may require additional tools.

The fact that the tool depends on the data you supply is an additional disadvantage. The design of the layout may not be accurate if the input details are incorrect or lacking. For instance, the design may become invalid if zoning regulations change and you fail to update them in the program.

6.3. Luma

6.3.1. Introduction

Luma is an AI for better visual storytelling in architecture and urban design. Designers and architects may easily create presenter animations from simple 3D models with this application. In the past, creating high-quality graphics required a lot of work and expensive software. This is made easier by Luma AI which automates much of the process and enables the quick and effective creation of realistic animations.

6.3.2. How Luma AI Works

The Luma AI is easy to use. Designers start by submitting their drawings or 3D models to the website. These models can be anything from little buildings to large city plans. It transforms the model into a real animation once it has been uploaded. Viewers may get a full picture of how the area would appear in real life because to this method which can capture a variety of elements including street layouts, surrounding environment and etc.,

Using natural lighting and shadows, the tool does more than just create simple animations. it makes designs come to life and makes the models appear as realistic as possible. People can better see the finished product, whether it's a single structure or a whole cityscape.

For animation creation, this AI normally takes less than 10 minutes to generate an animation. The animation generation time typically is based on the time of the day you use the AI and during pick hours it takes more than normal time to generate an animation for you. For example, for our project, it took 26 minutes to generate a 5-second animation. The animation duration time is possible to extend to more 5-second by simply writing a prompt and asking "extend to 15 seconds".

6.3.3. Why Luma AI is Perfect for Architecture and Urban Design

This AI is perfect for everybody, especially for those who are in graphic industry, like architects and urban designers that have unique project visualization needs. This AI addresses these issues which is making it simple to explain complicated concepts in an interesting and understandable manner. In architecture, this entails being able to present everything in a realistic, three-dimensional format, including interior designs and building materials. In terms of urban design, it requires visualizing entire districts or communities complete with street textures, lighting, and building elements.

6.3.4. Advantages of This AI

One of the biggest benefits of Luma AI is its ability to enhance presentations. Clients, city officials, or community members can see the project in a lifelike animation that conveys the project's vision clearly. This makes it much easier for people to imagine what the final design will look like and how it will interact with its surroundings. Furthermore, it can generate ideas at different times of day which is demonstrating how a building or region may seem under varied lighting circumstances. Creating animations from scratch is a time consuming process. Especially when attempting to achieve a high level of detail. It could reduce the time required to produce quality animations. Once the 3D model is uploaded, Luma's AI-driven tools quickly generate the animation.

This innovation enables designers quickly create multiple animation versions which is giving them the opportunity to come up with different design possibilities. Since designers no longer need costly programs or technology to create animations, this tool not only saves time but also money. Luma AI takes care of the difficult tasks instead to give designers more time to improve their ideas if needed.

6.3.5. Disadvantages of This AI

Although it has some amazing potentials, this has some drawbacks. The program may not be as accurate as physically created animations made by skilled animators because it mostly relies on AI. Designers maybe discover it complex or extremely detailed aspects are not always accurately represented.

7. Result and Discussion

The study examined at how three artificial intelligence technologies, PlanFinder, TestFit and Luma, may impact architecture and urban design. Each tool was tested for a specific purpose, such as constructing architectural plans, designing the site, or creating realistic animations. The studies revealed that these technologies can assist to accelerate design processes and improve creativity. However, they revealed limitations, such as the necessity for precise input data and the difficulty involved with managing large projects.

PlanFinder demonstrated to be quite effective in creating building plans. It generated various design possibilities in seconds after customers entered basic information such as room measurements and site size. For example, when set with developing a plan for a small home project, the program produced four full drawings in under 30 seconds. This tool is very useful for freshmen since it enables them to experiment with professional design without requiring extensive design abilities. Professionals might benefit from utilizing the tool to quickly test their early ideas. However, PlanFinder's efficacy is strongly dependent on reliable inputs. If the input dimensions or wall alignments contain mistakes, the produced designs may be invalid. This dependence on detail can be annoying, especially for individuals inexperienced with related to technology.

TestFit excelled in urban site designing which is making it easy to create site plans for any construction projects. During testing, the tool generated a complete plan for a residential site within minutes, factoring in zoning regulations, parking requirements, and cost estimates. The tool's ability to offer instant feedback is one of its strengths. For instance, when the number of units or parking spaces was adjusted during testing, the software quickly updated the layout to reflect these changes. This real-time adaptability is extremely useful for urban planners and designers who need to swiftly determine the feasibility of a project. However, TestFit struggled with more elaborate designs, such as large-scale developments that necessitated complex arrangements. Its major focus on clear layouts limits its ability to handle a wide range of urban design requirements.

Luma was particularly good at making real animations from simple 3D models. By uploading a simple architectural model, users could create realistic visualizations that explained the design. In one test, Luma turned a simple 3D drawing of a structure into a 10-second animation complete with realistic lighting, shadows, and textures. This made it simpler to deliver ideas to clients and stakeholders, allowing them to imagine the finished result. The ability to produce animations for multiple times of day increased its usefulness, allowing designers to demonstrate how their designs appear under varying lighting situations. However, Luma has certain downsides. During high usage, the tool needed longer processing times, with a single 15-second animation requiring more than 20 minutes to produce. Furthermore, the tool struggled to capture small features in increasingly complex designs, thus reducing its appeal for applications needing a high level of accuracy.

Table 2 summarizes the practical observations and outcomes of using the AI tools which is highlighting their effectiveness and limitations during testing.

Table 2 Observations from Testing AI Tools

AI Tool	Testing Observation	Outcome
PlanFinder	Generated 4 plans in seconds; required precise input for accurate layouts	Effective for quick iterations
TestFit	Successfully applied zoning rules and cost analysis; limited to simpler configurations	Ideal for early-stage site feasibility
Luma	Created detailed animations; longer rendering times during peak usage	Enhanced visualization with minimal effort

A major advantage of these AI tools is the speed they bring to the design process. Tasks that traditionally took hours or even days can now be completed in minutes. This allows designers to focus on refining ideas rather than spending excessive time on initial drafts. The tools also make design more accessible to people with varying levels of expertise. Beginners can use PlanFinder and TestFit to create professional-quality layouts, while experienced architects and urban planners can use them to quickly test and refine ideas. Luma's ability to produce visually stunning animations simplifies

communication with clients and stakeholders, bridging the gap between technical design concepts and public understanding.

Despite the benefits they provide, the tools have obvious limits. All three require very exact input data to perform properly. Inaccurate or missing facts might result in inaccurate findings that may take more effort to fix. Furthermore, these technologies are better suited for practical designs rather than extremely detailed or complicated ones. PlanFinder is excellent for making simple plans, but offers few options for changing the layout's appearance. In the same way, TestFit performs poorly on complex site layouts, but excels at preliminary design. Although Luma is helpful for creating animations, it is not accurate enough for showing exact textures or materials.

The application of AI in design poses societal and ethical concerns. These technologies decrease the need for human labor by automating repetitive tasks which may affect the career chances of new designers. Furthermore, AI algorithms have the potential to be biased, resulting in designs that neglect certain societal or cultural considerations. If an algorithm is based on data from a certain place, it may produce designs that are incorrect for diverse cultural or environmental conditions. These issues highlight the need of using artificial intelligence to improve rather than replace human innovation.

The study's findings also point to a variety of ways AI may improve sustainability in design. TestFit helps to optimize land use and reduce resource waste by providing real time zoning and pricing input. Similarly, PlanFinder enables designers to quickly assess several layouts, resulting in more sustainable space allocation decisions. Luma's realistic animations may help clients and communities grasp the environmental benefits of a design that encourages more sustainable practices in building and urban development.

To fully realize the potential of these technologies, several improvements are necessary. Improving their capacity to handle complex designs would increase their usefulness in a broader variety of applications. Furthermore, including local building regulations and zoning codes into this program would ensure that the context of the generated designs are correct. Addressing ethical issues like algorithmic bias and employment displacement should be prioritized. Developers must guarantee that AI systems are intelligible and inclusive, providing equal advantages to all users.

Looking ahead, the future of AI in architecture and urban design is bright. These technologies are likely to grow much more complex with live environmental data and advanced customization selections. Collaboration among architects, urban planners, data scientists, and ethicists will be essential for ensuring that AI is utilized ethically and successfully. Educational programs should also teach future designers how to utilize AI technologies wisely, stressing their role in strengthening, not replacing, human creativity.

8. Conclusion

This research focused on how AI technologies such as PlanFinder, TestFit, and Luma are changing architecture and urban design by reducing workflows, increasing creativity, and supporting sustainability. Each tool has its own set of strengths, from producing designs and site plans to creating realistic visualizations, all of which help to speed up and organize the design process. These technologies offer helpful answers to contemporary design challenges, but having serious disadvantages such reliance on data quality and restricted adaptability for large projects. By enabling more creative, effective, and inclusive design solutions, this research advances sustainable urban environments. To optimize AI's potential for societal good, future research should focus on enhancing tool flexibility and tackling ethical issues.

References

- [1] Ko J, Ennemoser B, Yoo W, Construction WYA in, 2023 undefined. Architectural spatial layout planning using artificial intelligence. Elsevier] Ko, B Ennemoser, W Yoo, W Yan, MJ ClaytonAutomation in Construction, 2023•Elsevier [Internet]. [cited 2024 Nov 11]; Available from: <https://www.sciencedirect.com/science/article/pii/S0926580523002790>
- [2] Architectus AJR, 2022 undefined. Artificial intelligence as part of future practices in the architect's work: MidJourney generative tool as part of a process of creating an architectural form. bibliotekanauki.plA Jaruga-RozdolskaArchitectus, 2022•bibliotekanauki.pl [Internet]. [cited 2024 Nov 12]; Available from: <https://bibliotekanauki.pl/articles/2174415.pdf>
- [3] Yussuf R, Buildings OAE and, 2024 undefined. Applications of artificial intelligence for energy efficiency throughout the building lifecycle: An overview. ElsevierRO Yussuf, OS AsfourEnergy and Buildings,

- 2024•Elsevier [Internet]. [cited 2024 Nov 12]; Available from: <https://www.sciencedirect.com/science/article/pii/S0378778824000197>
- [4] Almaz A, El-Agouz E, Sustainability MA, and undefined, 2024 undefined. The Future Role of Artificial Intelligence (AI) Design's Integration into Architectural and Interior Design Education is to Improve Efficiency, Sustainability, and. researchgate.netAF Almaz, EAE El-Agouz, MT Abdelfatah, IR MohamedSustainability, and Creativity, 2024•researchgate.net [Internet]. [cited 2024 Nov 12]; Available from: https://www.researchgate.net/profile/Mohab-Abdelfatah/publication/379665362_The_Future_Role_of_Artificial_Intelligence_AI_Design's_Integration_into_Architectural_and_Interior_Design_Education_is_to_Improve_Efficiency_Sustainability_and_Creativity/links/6620ecc043f8df018d165c55/The-Future-Role-of-Artificial-Intelligence-AI-Designs-Integration-into-Architectural-and-Interior-Design-Education-is-to-Improve-Efficiency-Sustainability-and-Creativity.pdf
- [5] Liang C, Le T, Ham Y, ... BMA in, 2024 undefined. Ethics of artificial intelligence and robotics in the architecture, engineering, and construction industry. ElsevierCJ Liang, TH Le, Y Ham, BRK Mantha, MH Cheng, JJ LinAutomation in Construction, 2024•Elsevier [Internet]. [cited 2024 Nov 12]; Available from: <https://www.sciencedirect.com/science/article/pii/S0926580524001055>
- [6] Jiang F, Ma J, Webster C, Chiaradia A, ... YZP in, 2024 undefined. Generative urban design: A systematic review on problem formulation, design generation, and decision-making. Elsevier [Internet]. [cited 2024 Nov 12]; Available from: <https://www.sciencedirect.com/science/article/pii/S0305900623000569>
- [7] Rane N, Choudhary S, Rane J. Integrating ChatGPT, Bard, and leading-edge generative artificial intelligence in architectural design and engineering: applications, framework, and challenges. 2023 [cited 2024 Nov 12]; Available from: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4645595
- [8] Cudzik J, Nyka L, Engineering JSJ of, 2024 undefined. Artificial intelligence in architectural education-green campus development research. mostwiedzy.plCudzik, L Nyka, J SzczepańskiGlobal Journal of Engineering Education, 2024•mostwiedzy.pl [Internet]. [cited 2024 Nov 12]; Available from: https://mostwiedzy.pl/pl/publication/download/1/artificial-intelligence-in-architectural-education-green-campus-development-research_89222.pdf
- [9] Verganti R, Vendraminelli L, Iansiti M. Innovation and Design in the Age of Artificial Intelligence. Journal of Product Innovation Management. 2020 May 1;37(3):212–27.
- [10] He W, Buildings MC, 2024 undefined. Advancing Urban Life: A Systematic Review of Emerging Technologies and Artificial Intelligence in Urban Design and Planning. mdpi.comW He, M ChenBuildings, 2024•mdpi.com [Internet]. [cited 2024 Nov 12]; Available from: <https://www.mdpi.com/2075-5309/14/3/835>
- [11] Ertel W. Introduction to artificial intelligence [Internet]. 2024 [cited 2024 Nov 12]. Available from: [https://books.google.com/books?hl=en&lr=&id=O7kfEQAAQBAJ&oi=fnd&pg=PR5&dq=Ertel,+W.+\(2024\).+Introduction+to+artificial+intelligence.+Springer+Nature.&ots=JnzDMuxjby&sig=yf8FMWMs30iuA2tBU60PD2bY7oI](https://books.google.com/books?hl=en&lr=&id=O7kfEQAAQBAJ&oi=fnd&pg=PR5&dq=Ertel,+W.+(2024).+Introduction+to+artificial+intelligence.+Springer+Nature.&ots=JnzDMuxjby&sig=yf8FMWMs30iuA2tBU60PD2bY7oI)
- [12] Ali S, Abuhmed T, El-Sappagh S, fusion KMI, 2023 undefined. Explainable Artificial Intelligence (XAI): What we know and what is left to attain Trustworthy Artificial Intelligence. ElsevierS Ali, T Abuhmed, S El-Sappagh, K Muhammad, JM Alonso-Moral, R ConfalonieriInformation fusion, 2023•Elsevier [Internet]. [cited 2024 Nov 12]; Available from: <https://www.sciencedirect.com/science/article/pii/S1566253523001148>
- [13] Schwendicke F, Arsiwala-Scheppach LT, Krois J. Artificial intelligence: what it is and what it can do for dentists. <https://doi.org/10.12968/denu.2023504245> [Internet]. 2023 Apr 18 [cited 2024 Nov 12];50(4):245–9. Available from: <https://www.magonlinelibrary.com/doi/10.12968/denu.2023.50.4.245>
- [14] PlanFinder [Internet]. [cited 2024 Nov 12]. Available from: <https://www.planfinder.xyz/>
- [15] TestFit: Real Estate Feasibility Platform [Internet]. [cited 2024 Nov 15]. Available from: <https://www.testfit.io/>