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New approaches of the Next-gen collaborative design platform

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Abstract

The architecture design process always changes because the software always updates with new tools and the development - innovation is in the first line of progress. The human-machine cooperation has become commonplace through Computer-Aided Design tools, but a more improved collaboration appears possible only through an endeavor into a kind of artificial design intelligence and Augmented Reality. According to all the above, the research shown in this paper the core ideas - identifying design specifications - of a next-generation collaborative design platform. The direct coupling of introducing multi-industry systems - tools, 3D databases, AEC, and Open-BIM technologies opens up totally new ways of approaching architectural design problems resulting in a new flexible modeling workflow with real-time visualization. Finally, this critical examination research makes an original contribution to changing 'attitude' towards the 3d modeling of architectural design thinking. A collaborative design platform creating a more efficient and versatile architecture.

Keywords: Architectural design process; 3d modeling; Open-BIM technologies; artificial design; real-time visualization.

1. Introduction

The world of architecture has undergone more changes than any other art form – not necessarily about styles. While many styles have come and gone, the techniques that substantiate them have shifted from pen and paper to the digital world.

As technologies evolve, so does our nature of imagining and visualizing our designs and thoughts. Computer aided design tools is heavily dependent upon visualization, so it is no wonder that new data visualization technologies like AR and VR would influence and enhance design thinking in leaps and bounds. “The Fourth Wave”, as it is termed in measuring technological growth of most industries. The real-time 3d technology for creating interactive and immersive experiences is emerging as a solution in our days after covid-19 pandemic time. The architecture design process always changes because the software always updates with new tools and the development - innovation is in the first line of progress.

This paper presents a new design process of 3d virtual interactive technologies using new techniques and tools like Artificial Intelligence and 3d real time Rendering Software. This research investigates with a critical perspective and recommends an easy-to-use WebGL-Based 3d Virtual Reality Roaming System which runs without the need for plug-ins or third-party components. Experiments in many domains show that this method has fluency and a strong sense of reality. This is mainly due to advances functionalities, capabilities and cost-effectiveness of instruments and deployment procedures for 3d modeling software, image-based-modelling techniques, and new tools of real time rendering engines.

According to all the above, there are opened new possibilities of Augmented Reality. This technology has novel and unique perspectives for real-time immersive experiences in design process. Additionally, the crisis caused by the global coronavirus pandemic has had a major impact on our mobility, and it is changing our habits. In the context of such limitations, the online accessibility and new digital techniques can be an effective solution for everyone.

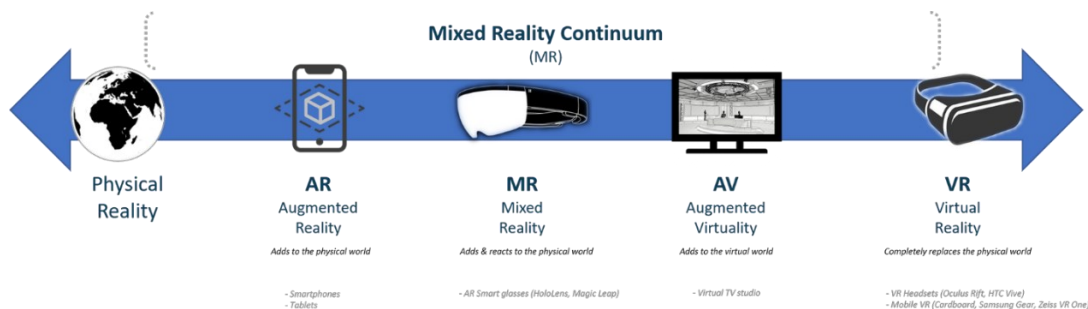


Figure 1. Diagram of all Extended Reality technologies (<https://www.tacton.com/>)

2. Rendering Software Using AR and VR

Rendering software is the software used in architectural visualization. It is an intricate, large, CPU and GPU intensive piece of software that brings architectural models and buildings to life. By using rendering software, architects can present their models in a realistic 3D environment – which can later be used for modifications to the original design, marketing, and presentation purposes.

In exact terms, rendering software is a computer program that generates high-quality computer images from models.

Rendering, as a process, requires a lot of processing power. The software uses complex algorithms to generate photorealistic stills of models. Using these algorithms, designers can present their work in a simulatory, realistic, well-polished manner. Rendering has many uses aside from marketing and presentation, such as design revisions. Two main hardware components go into rendering – the central processing unit and the graphics card. Many people prefer to use the GPU for rendering, as it streamlines the whole process and provides arguably better results in some cases.

Real Time Rendering is pretty much exactly what it sounds like: animations that are rendered so quickly they appear to be being generated in absolute real time. But to fully understand what is really going on under the hood, first we will have to talk about the pipeline.

The graphics rendering pipeline, which we will now and forever simply refer to as “the pipeline,” has nothing to do with surfing or the rapid transportation of natural gas or crude oil. The pipeline represents the foundation of any visualization or rendering engine. It is where the rendering of all 3D objects, light sources, lighting models, textures, cameras and more happens. Some also refer to it in layman’s terms as “the magic.”

Specifically, the real-time rendering pipeline consists of three conceptual stages: the application stage, the geometry stage, and the rasterizing stage. The end result is an animation that is rendered in what appears to be real-time and is measured in frames produced per second.

Now, real-time rendering is nothing new. Anyone who is picked up a videogame controller has experienced it first-hand. The videogame industry has been implementing real-time rendering in games for decades, but only recently have designers and architects started using some of those techniques to present their ideas.

But why has it takes so long for the design and architecture industries to adapt this technology? Why are so many firms stuck in the stone age with static images and spliced together animations that read more like diagrams than immersive representational experiences?

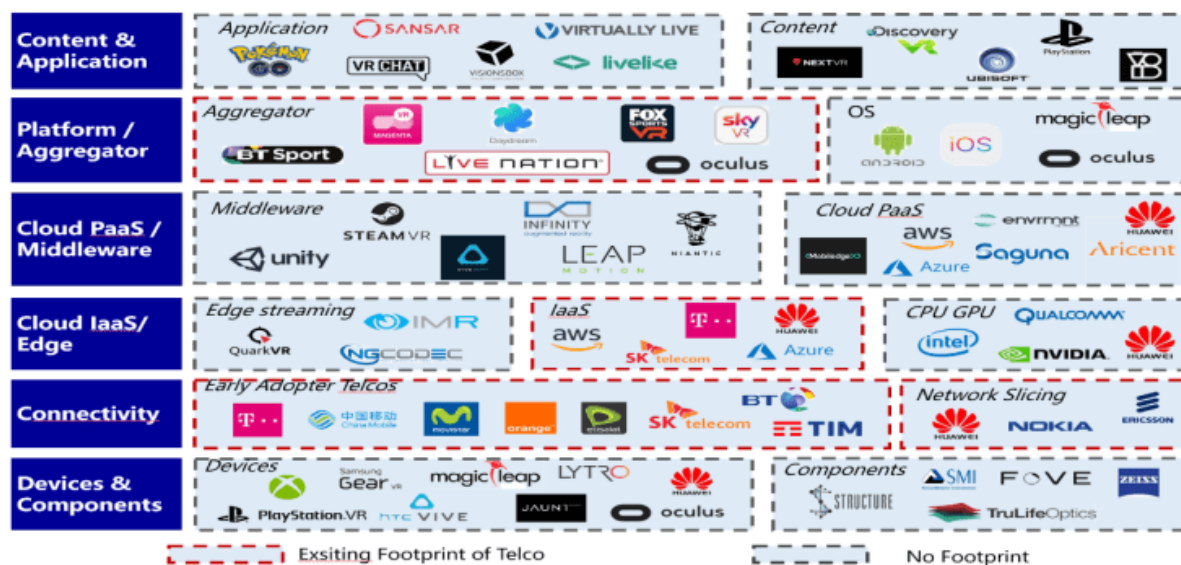


Figure 2. The AR/VR industry value chain has six distinctive segments (<https://www.gsma.com/futurenetworks/>).

2.1. How can BIM relate to VR and AR

Construction design is heavily dependent upon visualization, so it is no wonder that new data visualization technologies like AR and VR would influence and enhance BIM (Building Information Modelling) in leaps and bounds. We are indeed standing on the brink of a major breakthrough in terms of construction design process with AR and VR – and arguably, BIM would be the system benefitting most from this.

Solid modeling is difficult to make adjustments to, therefore, parametric modeling is emerging in its place in architectural heritage. BIM aims to ensure the efficiency of construction, management, and monitoring of the

designed building. BIM has to a certain extent become the boundary object between the architect and related engineers.

BIM represents an object to be created in a digital universe. It holds the precise data about the object's physical and functional characteristics, and acts as a model of the following: Design, Program, Realization, Maintenance.

The above is true for any construction projects which utilizes a digital system of information modeling, containing information about various objects throughout their construction lifecycle.

Since all the information is digital, AR would be insanely helpful in BIM, with the support of right hardware.

Even at the very beginning, surveys would become ridiculously easy, when you just stand in middle of the site and look at different places, and the detailed survey data gets embedded in the project model.

In the modeling phase, an architect can just stand in space and add walls and columns by hand in a virtual 3D model. The BIM model gets calculated accordingly.

The engineers can then "walk through" this virtual model and make it fit the bill, fixing, and adjusting the model as necessary. Estimators can input advice just looking at portions of the building and realizing its cost.

And at the construction phase, it gets so obvious how AR and VR can help BIM. How easy and fast the construction process be, if you can just look at a bean and know all about it? Add drones in the equation that can look at objects that are difficult for you to reach, and you can virtually fly around and through the building, an omniscient entity.

The spatial and geometric nature of the data used in BIM makes it especially responsive to the effects of VR and AR; and so, the construction design will leave the tables and go into 3D glasses. May require more walking around, though!

3. Real-time rendering and digital design tools

3D rendering is the process of producing an image based on three-dimensional data stored on your computer. It is also considered to be a creative process, much like photography or cinematography, because it makes use of light and ultimately produces images.

With 3D rendering, your computer graphics converts 3D wireframe models into 2D images with 3D photorealistic, or as close to reality, effects. Rendering can take from seconds to even days for a single image or frame. There are two major types of rendering in 3D and the main difference between them is the speed at which the images are calculated and processed: real-time and offline or pre-rendering.

In real-time rendering, most common in video games or interactive graphics, the 3D images are calculated at a very high speed so that it looks like the scenes, which consist of multitudes of images, occur in real time when players interact with your game.

That is why interactivity and speed play important roles in the real-time rendering process. For example, if you want to move a character in your scene, you need to make sure that the character's movement is updated before drawing the next frame, so that it is displayed at the speed with which the human eye can perceive as natural movement.

The main goal is to achieve the highest possible degree of photorealism at an acceptable minimum rendering speed which is usually 24 frames/sec. That is the minimum a human eye needs in order to create the illusion of movement. Even though rendering is based on tons of sophisticated calculations, modern software's can offer some fairly easy parameters for you to understand and work with. A rendering engine is usually included in a modern 3D game engine and it can achieve really amazing graphics.

Digital design tools are omnipresent in design practice and have helped architects both past and present to explore the functional and formal solution space for architectural problems. Consequently, these digital aids span from dabbling to construction and are already beyond the constraints of pen and paper or other conventional media. Digital design tools were predominantly developed by fostering the capabilities of conventional tools in such a way that they appear as a logical enhancement from their predecessors. However, this legacy also introduces a constraint that is inherent to the physical nature of conventional design tools. The objects to be designed can either be virtual or real. With the use of MR and AR in particular the question arises how both virtual and real can co-exist in a meaningful way. An initial milestone in the research of collaborative digital design tools was created by Bradford et al. (1994) coining the term the Virtual Design Studio and identifying means of communication as a key factor for design within new media. Hence, research about digital design started to focus on probing and observing of different media provided by emerging interface technology. Hirschberg et al. (1999) looked at the utilisation of time zones for a virtual design process and investigated the impact of the time shifts on the design process.

Various new developments in computing, visualisation and modelling technologies allow Architecture, Engineering, and Construction (AEC) Industries to make use of novel techniques that merge real life situations with computer generated visual information to combine real and virtual spaces (Anders, 2003).

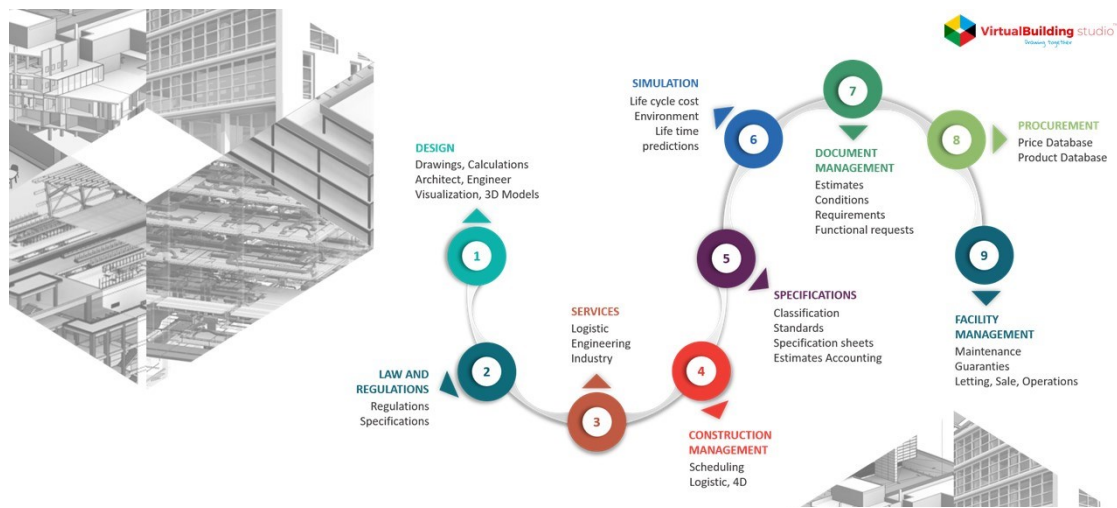


Figure 3. Significance of BIM in the AEC Industry (<https://www.virtualbuildingstudio.com/>)

Currently, architects, designers and engineers use a variety of instruments to bridge the gap between the idea of a design and its representation hence linking an idea, its communication and realisation. Any tool demands different responses from of the designer, and each instrument introduces different reinterpretations of the design. Subsequently, inherent characteristics and affordances impose a divergence between the idea and its expression. As the AEC industries integrate increasingly digitally managed information and Building Information Systems (BIMs), more intuitive visualisation platforms are necessary for efficient use of such information. Recent advances in computer interfaces and hardware instruments have fostered MR prototypes to improve current architectural visualisation, design communication and processes, development of building construction, and engineering management and maintenance systems. The combination of real with virtual entities creates mixed environments that could enhance and aid these processes.

3.1. Real-time rendering software

When creating an interactive project for example in Unity program (<https://unity.com/>) or in Unreal Engine - Twinmotion (<https://www.unrealengine.com/en-US/>), you can go from luminous day, to gaudy glows of neon signs at night; from sunshafts, to dimly lit streets and shadowy tunnels, to create that evocative atmosphere that enralls your audience. No matter if want to develop a 2D or 3D game for mobile or a console game, Unity's Scriptable Render Pipeline (SRP) allows you to establish gorgeous imagery and optimize for specific hardware. For example, there is the High-Definition Render Pipeline (HRDP) which targets high-end PCs and consoles, and there is the LightWeight Render Pipeline (LWRP) which targets mobile (Unity3d Blog, <https://blog.unity.com/technology/the-lightweight-render-pipeline-optimizing-real-time-performance>).

Rendering is being used in all kinds of art. Anything from industrial design to architecture makes use of rendering software – meaning as the software advances, so does the industry. Rendering software is not exactly the cheapest thing on the market, so it often takes some corporate financial backing to get the proper tools.

Through this investment, rendering tools are continually improving, though. With the advanced on-going sophistication of rendering software, the tools themselves are getting more sophisticated with each passing update. Things that used to take hours of effort and years of learning and determination can be streamlined to a couple of seconds. Alternatively, as time passes, the potential computing power of many PCs is skyrocketing, turning rendering into a relatively fast process.

However, with artificial intelligence, rendering software can become one with the designer that is operating it – improving performance, simplifying operation, and streamlining the production process as a whole.

Additionally, the world's most open and advanced real-time 3D creation tools – until now - are:

- Twinmotion Abvent (<https://www.unrealengine.com/en-US/twinmotion>)
- Unity (<https://unity.com/>)
- Enscape 3d GmbH (<https://enscape3d.com/>)
- LumenRT (<https://www.bentley.com/en>)
- Lumion Act-3D B.V. (<https://lumion.com/>)
- Unreal Engine - Epic Games (<https://www.unrealengine.com/en-US/>)
- Autodesk 360 (<https://a360.autodesk.com/>)
- CL3VER (<https://www.cl3ver.com/3d-app/>)
- Amazon Lumberyard (<https://aws.amazon.com/de/lumberyard/>)

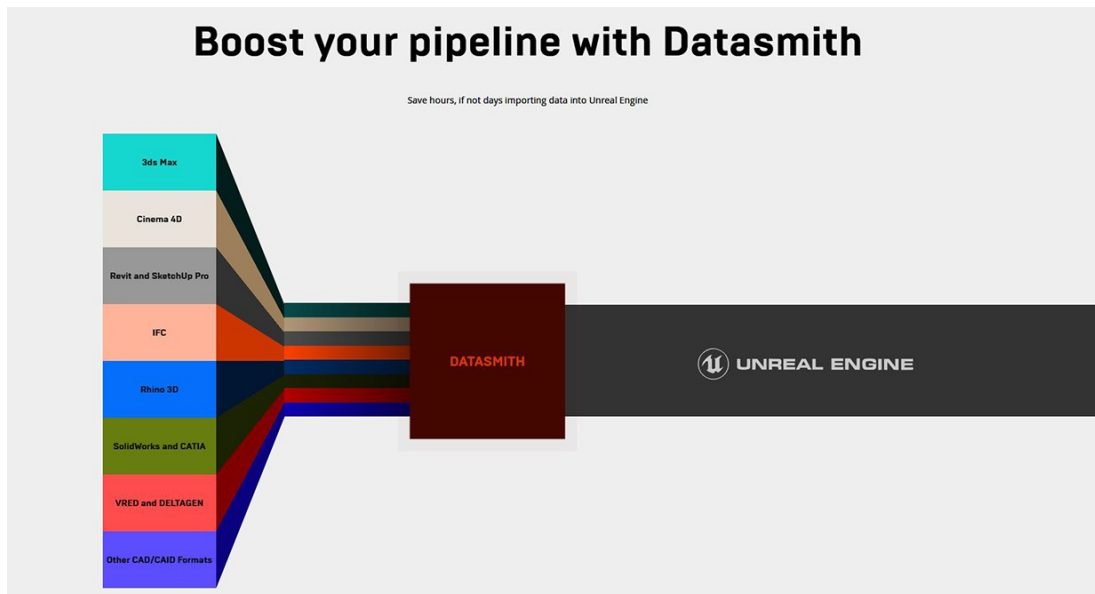


Figure 4. Datasmith is a collection of tools and plugins that bring entire pre-constructed scenes and complex assets created in a variety of industry-standard design applications into Unreal Engine (<https://www.unrealengine.com/>).

3.2. The future of rendering visualization

The future of rendering is not necessarily moving toward more and more exact realism. Architectural visualization is a medium for communication, and like any means of communication, it conveys not only information, but also emotion. Still, new technology, like virtual-reality headsets and augmented reality, seem to be pushing expectations in a new direction. “We put so much time and effort into crafting these images,” Hodgson says, “that you wonder whether there is going to be a need for what we do in five years.”

The answer is not to blindly adopt new technology simply because it is there, but to experiment with how new media can supplement existing practices and how the magic and ambiguity of painterly effects can be brought to life in new machines. Hodgson showed off a 360-degree image that can be explored by looking “through” an iPad.

The view changes as the tablet are moved around as though it were a window into the virtual space. The effect was much more pleasant than the often slightly nauseating experience of wearing a VR headset; it was more like reading out of a magic picture book. It has already been very successful in public review processes, Hodgson says, with the enchantment of the experience winning over skeptical and often conservative crowds.

A central objective is the development of an overarching methodology for the “co design” of methods, processes and systems based on interdisciplinary research between the fields of architecture, civil engineering, engineering geodesy, production and systems technology, computer science and robotics, as well as the humanities and social sciences.

4. The Development of Artificial Intelligence

Artificial intelligence is one of the most interesting, buzzing, and rapidly developing technologies of this decade. We have come so far in our technological advancements that today, we are able to emulate the full human experience through the use of machines, programming, and artificial intelligence.

Remember deep blue? IBM’s chess-playing computer. It was a supercomputing technology that was revolutionary. Well, a high-end smartphone today has more processing power than the world’s most popular supercomputer, which was built only two decades ago.

Technology is advancing at a pace so rapid that we cannot keep up with it, and AI is the next logical step in the computing world.

Today, AI is used to streamline many processes that go on in the background. Through AI and machine learning, programs can learn to adapt to our jobs and make tedious tasks accomplishable at the click of a button.

It is tough to tell what AI might bring to the table next, but whatever it is, it is going to be nothing short of a complete technological revolution.

AI streamlines, simplifies, and improves rendering, and might propose the necessary solutions that are required to take architecture into its new golden age.

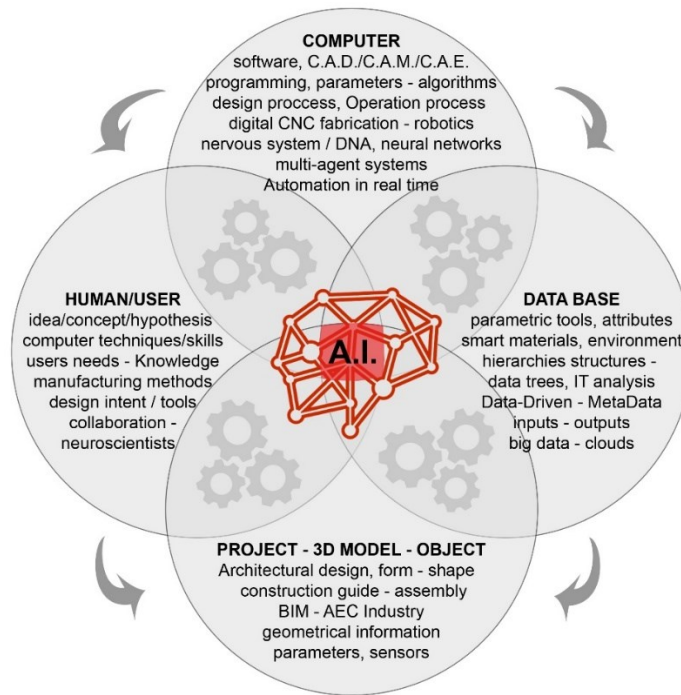


Figure 5. Development of Artificial Intelligence (Developed by Author).

4.1. Potential Benefits of AI Rendering

AI is one of the up-and-coming technologies of the future. the AI revolution is ultimately good for the workforce, the economy, and especially architects. Artists can use AI to streamline many processes that used to be time consuming, laborious, or simply boring – making the whole design process simpler, faster, and more efficient.

Concerns and genuine fears aside, there are many-a good things that AI rendering could bring to the table. In this section, this paper will cover some of the most promising benefits that AI could produce in the next couple of years. All these benefits are from the architectural perspective, but the list of benefits does not end with this selection. It has merely highlighted the most important benefits for architects, but the list goes on.

- Faster Rendering

Rendering is a very time-consuming process. It requires a substantial amount of computing power, which stems either from the CPU or the GPU. Through the advancement of hardware, this process is streamlined and takes a substantially shorter time.

However, this process is not only slow because of hardware limitations. The software that devises and implements the advanced algorithms required for rendering could be improved significantly, especially by introducing AI and machine learning.

Through AI and machine learning, rendering can be sped up massively. The time it takes for AI to devise a solution and implement it during the rendering process is far shorter than merely relying on a hypercomplex algorithm.

Through the introduction of AI, rendering can be sped up, simplified, and streamlined to a far greater extent than its current state.

- Automated Editing

Editing is a long process in itself, but the effort is not the only thing that comes into play. The time needed to render edits and process input information can be very long, especially when combined.

Alternatively, some edits are near impossible to accomplish in a particular time frame due to technological limitations. AI could home in on this issue and provide the necessary solutions that artists can use to streamline and even automate their editing.

AI promises to bring many instant solutions to prevalent problems when it comes to editing, especially in design and architecture. Rendering makes manual editing simple, but AI-enhanced rendering could potentially remove all the manual work from the editing process, which brings us to the next point.

- Less Manual Labor

Designing, optimizing, editing, and exporting an architectural design is laborious, time-consuming, and requires lots of effort. There are many tools and programs that significantly cut down on all these factors and streamline the process, but through the introduction of AI, the whole landscape is due for a complete change.

AI and machine learning can work alongside the designer and help them automate as many processes as possible. Things that used to take a lot of time and effort could be solved with a push of a button, thanks to artificial intelligence.

With less manual work required to produce a high-quality architectural render, architects can devote more of their valuable time to developing their design to a higher degree of sophistication.

- Easy Flaw Detection

Flaws tend to happen more than you might think, especially when you are rendering. That is why rendering is the primary way for architects to detect flaws with their design. Artificial intelligence will provide the necessary programming to detect possible flaws so that the designer can fix them in due time.

Everyone makes mistakes – it is how you deal with them that counts. Mistakes in the architectural design process can be downright disastrous if unnoticed.

There are many regulations, rules, and laws put in place that define the restraints of what an architect can do. While something might be lovely as a 3D render, it could be too expensive, dangerous, or complex for the real world.

Finally, through AI and machine learning, architects can easily spot any flaws and mistakes in the design and could resolve them at a faster pace due to automated editing.

5. Making the Design Process a Better Workflow

The design process is all about a continuous loop of trial and feedback, trial and feedback, trial, and feedback - until you are either up against a deadline or run out of money. Good architects and designers champion their process with the highest regard, as it is the engine that powers their entire production machine. And if the process is the engine, the feedback is the oil - the lifeblood that makes all the other parts work. Feedback tells you what is right and what is wrong, and analyzing it tells the designer how to make things better. Real-time rendering would provide the designer with the kind of audio-visual feedback unlike anything we have seen before.

The idea is this: an architect would invest in people familiar with real-time rendering technology that would build an interactive world around the site of any particular project. At the onset of a project, this interactive environment could be used by the design team to test concepts, ideas, and ultimately fully fledged experiences that revolve around the thing that will eventually be built. The feedback goes from being a preconceived judgement of a static object, to an unpredictable emotional and physiological response to something that assaults the senses with information regarding light, space, material, and procession simultaneously.

Furthermore, the recent surge in virtual reality technology takes this feedback loop a substantial step further. It has the potential to add layers of depth and output that will have designers reacting and making design decisions based on an almost 1:1 analogous experience to what is to be a realized building.

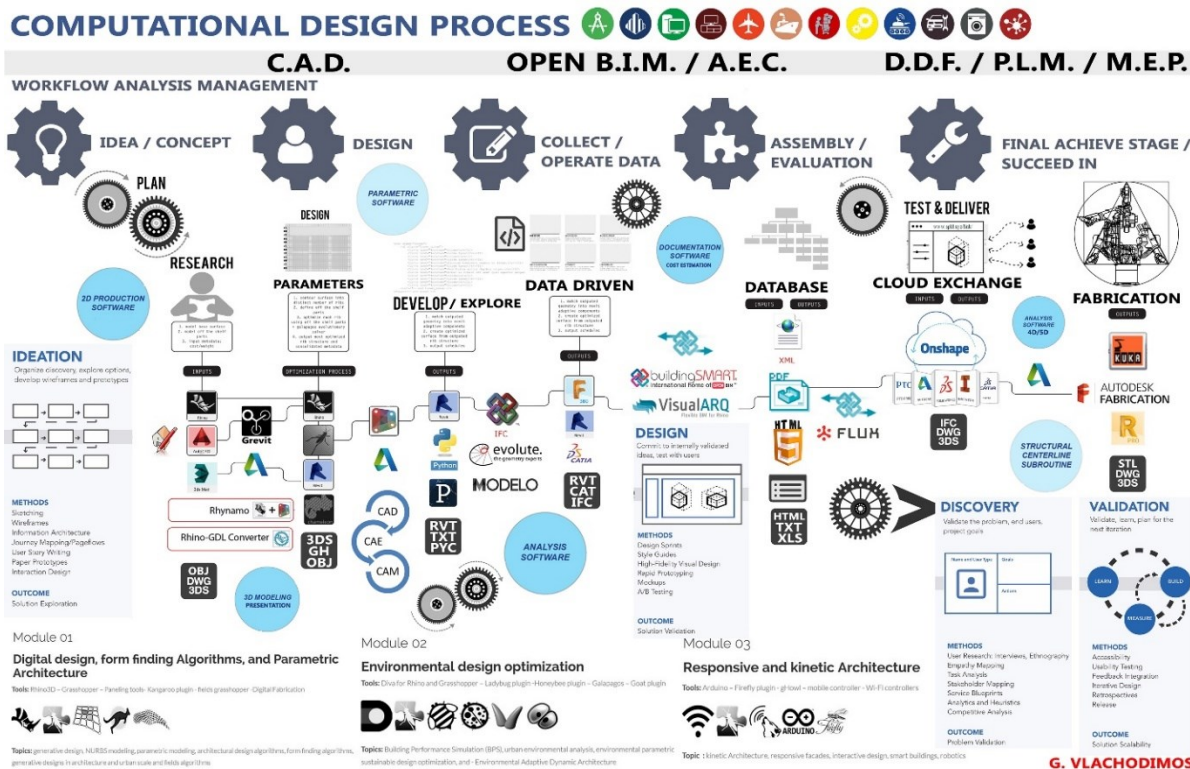


Figure 6. Many ways-workflows of design process. Workflow diagram. (Developed by Author).

6. Designing a next generation collaborative platform

In this paper will explore the interactive relationships around software design in relation to the design of flexible parametric models, improve them and whether they are possible collaborations with other industries. Specifically, analyze more ways design process via computer, and ways – techniques, processing have epistemic and aesthetic impact on the design and making of architecture.

The 'clever' and proper use of various programs and technologies can bring the desired result in a quick and easy way to design. The storage and retrieval of design data through databases, the workflow, and the exchange of information through cloud technology, the open-source programming platforms in conjunction with parametric programs and software of B.I.M. and A.E.C. industry (through I.F.C. protocols) can bring flexibility to architecture process.

A collaborative design platform will be classified as successful if it involves and supports most of these features, so that different user groups of scientists can adopt it. Additionally, it can further enhance the possibilities to explore new areas in the design process. The technological developments of the last decade set the framework for a new approach to the same concept.

In collaboration computational design, configuration and database shows a new design to which contribute many disciplines, from computer science to the science of materials, which reaches a depth of biology and chemistry.

The 'new' architect, to be able to succeed on his role, should have knowledge in many areas. Because the planning process realizes the building as a whole, so to be able to 'visualize' and designed a project must have in mind from the beginning that all these tools combine and use that is given.

By combining computational design, smart materials and parameters emerges a new vision of design starts, which includes variation information, interaction with the user as well as a point artificial intelligence (AI). With the continuous exchange of information and data flow is achieved interaction while combining computational design and databases to some extent the notion 'intelligence' as a correction of some errors in the design process.

The opinions on the existing new ways of design, composition and thinking, are divergent. In this paper, supported the strengthening of a research field with a target variable parametric and interactive architecture and construction control that meets the greatest desires of man - user. This can be achieved by a combination - cooperation of different - but with so much in common - branches as previously reported. Their role is not to replace the 'traditional' ways of planning and construction, but to develop and strengthen them.

It is believed that the collaboration of various specialties under the protection of the systematic process could improve the quality of architecture and the application of modern tools, in not only theory but also mainly in practice; it will help to understand planning activity as a point of intersection of research, management technology and its parameters.

7. Conclusion

Architecture today is a multi-skilled profession, calling on disciplines from structural and environmental engineering to social and material sciences.

The purpose of this research is to investigate whether the software design can inform the design of flexible parametric models automatically in real time. The «common ground» between programming and parametric modeling in architecture. The practices of software engineering can be connected to the practices of parametric modeling, to create intelligent parametric models and to consider the implications of this relationship for architecture in general.

In the present study, a methodology is presented on how software engineering and computational design can instantly update parametric modeling in a flexible, automated way. Researching the main aspects of the structure of software engineering, such as structured programming languages, computational intelligence, parametric programs, B.I.M. – A.E.C. industries, and interactive online new design technologies, analyzes their contribution and their possible connectivity to the overall architectural and engineering design. In this way, by working together and collaboratively, a new parametric modeling method will be created.

In order to investigate the smooth operation of this case, a thorough analysis of the terms and the identification of the essential functions on architectural design and their contribution to the automation of tools to facilitate designer users are made.

The proposed collaborative platform will allow architects to share their ideas effectively, their design models, store and retrieve design data, optimizing the whole process. Supportive of an Open-Source collaborative platform for immediate optimization of design time and cost, and overall improvement of design quality, leading to better design solutions and architecture in general...

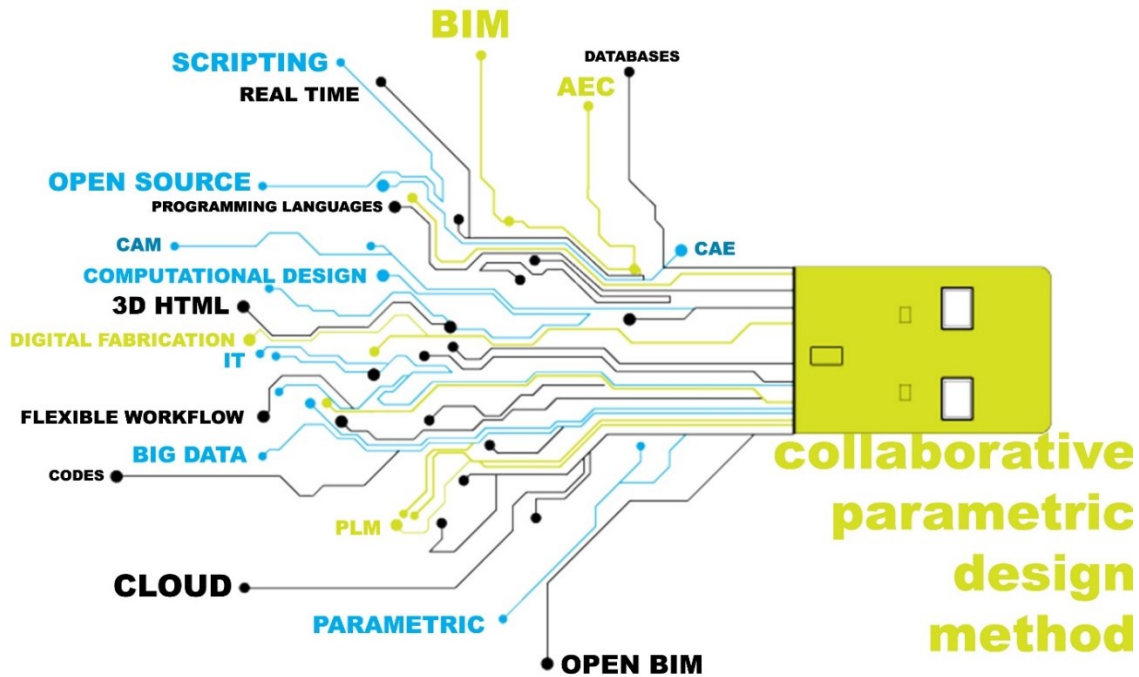


Figure 7. Keywords for the next generation collaborative platform (Developed by Author).

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Conflict of interests

The authors declare no conflict of interest.

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