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Architectural Design Method Suggestion with Machine Learning Technologies Based on Voronoi Diagram Principle

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Abstract

Today, computer and new art themes are important resources that can reflect its own logic to architectural design inputs and architectural products by opening new horizons in architectural concepts. The fact that art, and therefore architecture, has started to benefit from digital technologies that change the boundaries of life and can be produced with digital media tools, creates a new conceptual discussion and application environment open to development, transformation and experimentation. In the literature, many theories have been produced on the development of digital art, architecture and technology. However, studies should be conducted on the effective/possible methods in architectural design such as digital technologies and digital arts, interactive/text-based artificial intelligence interfaces, and how these methods will transform and change architectural design and architectural identity. With the creation of the architectural form through text-based artificial intelligence interfaces, a new design and production process is envisaged for the discipline of architecture with its possibilities such as autonomous and rapid alternative generation according to various contexts. In this study, architectural plan and form experiments were carried out with the principle of Voronoi diagram, which is a productive and algorithmic system with text-based artificial intelligence interfaces. In this context, it would not be wrong to say that the Voronoi diagram is fractal representations for the resulting products obtained in a fast and autonomous process with multiple alternatives. Architecture, which is in a constant transformation depending on time, technologies and users, will seek a new aesthetic with new production and expression techniques.

Keywords

architectural design, artificial intelligence, digital architecture, generative art, Voronoi Diagram

1 Introduction

With the second half of the 20th century, virtuality, which means "breaking from the original and disconnecting from reality", as a concept specific to the electronic environment, entered our daily lives with the development of digital technologies and came to the fore with computers (Atalay et al., 2000). The relationship between virtual and physical has been one of the most important points in digital arts and architecture using digital technology. Artists and architects, who focus on this relationship, study the concept of abstraction. Some artists perform, design events and even dance in venues that they create that combine virtual and physical. Many are designers who present hybrid virtual and physical spaces by applying the arts of installation; they want to emphasize the importance of experiences embodied in the digital environment (Bolter and Gromala, 2005).

Although many different fields have contributed to the development of contemporary approaches in design research, the two main fields of study that have guided design research have been design cognition and design computational models. While design cognition studies the cognitive process of design and the modeling of information structures, computational design models study systematic methods and approaches to design (Oxman, 1996).

Beginning in the 1980s, mainly from the 1990s, architecture has been transforming into a field that encompasses largely screen-based digital hardware. In this process, art covers the basic idea of the event. Artists are involved in interactive dynamic media systems. They are now creating environments and spaces that act as an intermediary-system to create a new social expression by contacting scientific institutions in order to advance in their field. The basis

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of interactive environments is based on a common system form that works with the help of interfaces that provide interactivity, acts as a bridge between the person and the outside world, whose activity is not completely pre-programmed. Product tools from the real world, in the form of inputs and access devices perceived by various sensors, screens and all other perceptual mechanisms that come into contact with the user are the basic elements of this environment. All these connections are a multi-system that encompasses perceptions (Doesinger, 2008). According to this system, the question of what happens next for architecture constitutes the starting point of this study.

What is at issue for today's architecture is the effectiveness of new forms based on interdisciplinary collaboration. An interactive environment is created by the collaborative creative work of artists, architects, designers and other experts (such as software engineers). Interactive environments, like virtual reality projects, are bridges between physical reality and virtual reality, rather than being entirely computer-generated. In the literature, such studies have been the area of interest of media artists. However, architects have also for some time absorbed digital techniques and technology, turning architecture into a real-time tool and thus bringing it closer to digital media. This has been one of the factors that enables architecture to be considered as a cultural activity. Digital technologies are now fed by a combination of different disciplines (Bullivant, 2005).

Today, when designs made through artificial intelligence and autonomous productive interfaces have started to replace contemporary art and design practices, there is a tendency towards production with artificial intelligence, which is a new agenda for the discipline of architecture. In this regard, studies are carried out with software languages in which the codes are written, but with this study, multiple alternative architectural design production experiments were carried out with text-based artificial intelligence bots to get results quickly. In this direction, the skills of artificial intelligence bots, which create a process in which multiple alternatives are produced, were compared, and architectural and visual quality evaluations of the results were made. The aim of the study is to question whether the artificial intelligence bots used will be a new method for architectural design and to create a discussion area for the possible effects of the digital environment on art and architecture.

Recently, due to the complex and ever-evolving organic nature of the architectural design process, the idea of starting the design process by connecting and integrating various data information from all disciplines has been studied. Designers begin by working on concrete information integrations that unify theory. In a way, it can be said that designers primarily design to think (Bokalders and Block, 2010). Due to the holistic and complex nature of the architectural design process, productive systems and algorithmic systems have been reached as a result of the search for a suitable method to expand the design with the same rules by including the newly added data in the system, which can manage the data, which are parts of this structure, simultaneously, parametrically, in the same language, in the architectural design process. In this study, the Voronoi diagram, which is a productive and algorithmic system, is used as a single sample as the scope of the study in order to enable the algorithms to make correct generalizations and provide alternatives in this direction and to make comparisons to artificial intelligence bots (Midjourney, DALL-E 2, Craiyon) that will be used as a tool to reach architectural representations, has been determined. Voronoi was chosen because it emerges as an algorithmic and productive system. In order to get efficient and meaningful results while producing the desired production from artificial intelligence bots, "Voronoi", a diagram with an algorithmic and productive setup, is given as one of the keywords to these interfaces as a way of thinking, thus it is aimed to reach a multi-alternative result. The selected interfaces are text-based worker bots named Midjourney, DALL-E 2 and Craiyon. The meaning of the style and skills of these bots for the discipline of architecture will also be discussed by conducting the same experiments on different interfaces. This study will open the effect of digital and productive art for architecture to conceptual discussion and will developed a new method proposal for the discipline of architecture with the results of the experiments.

2 Digital art and architecture

Digital art, which is formed by the combination of digital media and art, is an art form in which the computer plays a role in its production. In this process, the computer can be found anywhere in development, from a traditional auxiliary tool to its creative position (Purves, 2005).

While digital art relies heavily on science and technology for its design and physical content, digital artists argue that they create their work thanks to the advancement of technology. The adjective "digital" of art, which is considered as a creative reflection of modern culture, is generally used for works in which the computer is used as a tool/media/creative support, since it does not precisely determine the form of the work (Wands, 2006).

The use of computers for the design of works of art dates back to the 1960s. Michael A. Noll, a researcher at Bell Laboratories, created the earliest computer product images—Gaussian Quadratic, 1963—as part of the "Computer Product Images" exhibition at the Howard Wise Gallery in New York in 1965. Bela Julesz Georg Nees and Frieder Nake, who have works in the same exhibition, are also among the first artists of the same medium. Although their work is more like abstract drawings and aesthetic forms resembling traditional media, they have also captured the most important aesthetic elements of digital media by using the basic mathematical functions in the process of "digital drawing". The work of James Whitney, Charles Csuri, and Vera Molnar in the 1960s has also been very influential in today's research, as it contains elements of the relationship between mathematical functions and computer product transformation (Fig. 1) (Paul, 2008).

The 1990s witnessed an unprecedented rapid technological change in the digital environment. Although the basis of many digital technologies dates back to 60 years ago, the widespread use of these technologies corresponds to the last 10 years of the 20th century. In this period, while hardware and software were more elaborated and their accessibility increased, the development of the World Wide Web (WWW) added the concept of "global connectivity" to the 1990s. Artists have always taken pioneering steps in reflecting the culture and technology of their era. They were producing works in the digital environment decades before the official announcement of the digital revolution. However, towards the end of the century, "digital art" has become an established term and museums and galleries around the world have begun to collect these works and organize exhibitions where digital art products have been displayed (Paul, 2008). In the 1990s, digital arts continued to progress at a rapid pace. Hyper Text Markup Language (HTML) was developed in 1992. In 1993, the first Digital Hall was opened in the New York Art Directors Club, and then interactive art using digital technologies began to enter all forms, including cinema. "Osmose" (Fig. 2), the virtual reality medium of 1995 by Charles Sommerer and "Ephemere" of 1998, created new frontiers in digital art (Art Week).

Digital art is a fairly new phenomenon, but many of its features come from traditional art practices. It is expected that classifying and categorizing digital art by existing established methods will be eliminated by trying to understand more deeply the techniques and goals of its creation. As digital art begins to occupy an important place in the contemporary art world and we become more familiar with the language and syntax of computer technologies, we will be way more equipped to identify its forms and cultural contributions (Purves, 2005).

One of the current agendas of computer technologies is artificial intelligence. The essence of the concept of artificial intelligence dates back to the Greek philosopher Plato, who argued that the world of perception is a copy of an abstract reality. This idea, which was later developed by Descartes in the 17th century, was strengthened by the arguments that knowledge can head to some extent that we can distance ourselves from our perceptions. These ideas were taken up again by the artificial intelligence movement, which was the most dominant paradigm trying to analyze and understand the computer from the 1950s to the 1980s. Artificial intelligence experts have defined the aforementioned intelligence as a computer program that concretizes soft information with logical interventions and transforms it into an algorithm (Bolter and Gromala, 2005).

The most important feature of digital application is that information can change, develop and reorganize in various contexts and generate new ideas with different

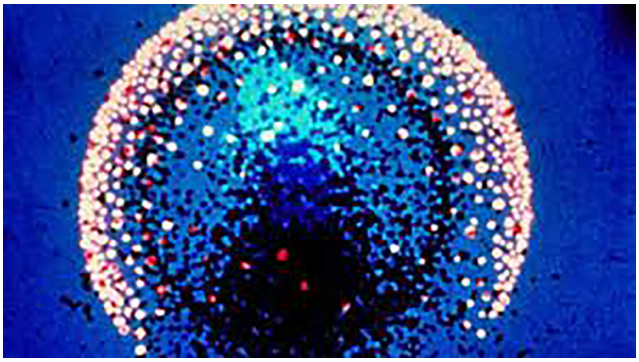


Fig. 1 "Yantra", James Whitney, 1957 (adapted from Wands (2006))

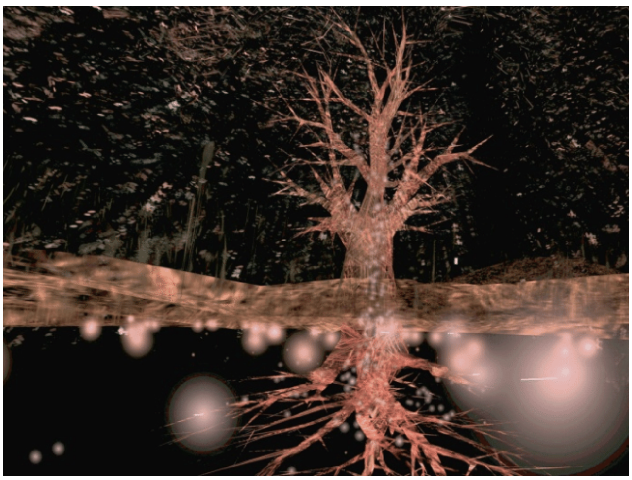


Fig. 2 "Osmose", Char Davis, 1995 (adapted from Art Week)

combinations. The ability to rearrange information in various contexts is entirely dependent on the database system, and this feature can be found in any digital artwork. A digital art object can be defined as one or more interfaces to a database in a multimedia environment. This definition tells that the virtual object is connected to an interface that allows the user or viewer to experience it. The word interface now almost means tools and methods that allow users to interact with a three-dimensional virtual environment of a computer program. Digital interfaces are systems that bring two different contextual orders closer to each other and communicate/interact (Paul, 2008). Over the past decade, some digital designers have referred to their work as "interactive design". This is a concept that describes the relationship process between the computer and the user, not applications consisting of static screens, for example. Interactivity designers should actually think like screenwriters writing dialogue for a movie or theater, but there is a difference: In a movie or theater play, the dialogues are fixed. However, in a digital interface, user options create different visual and textual responses on the computer, increasing the possibilities. A digital product is designed to express itself in a variety of ways. The best digital design in this direction adapts itself to user preferences rather than forcing the user to proceed in a certain scenario. These types of digital art products are interactive design experiences. They show that interface, information, content, and form are inseparable notions (Bolter and Gromala, 2005).

The use of digital technologies as an artistic tool and medium means that these works use completely the digital platform from production to presentation and showcase and reflect the possibilities of this platform. The possibilities of this digital environment offer the aforementioned aesthetic form: interactivity (participatory, dynamic – responsive – or adaptive work). These possibilities can also be used for the discipline of architecture, and they cause a transformation in architectural design methods.

Traditionally, architecture is concerned with a scope of equipment, form, and ground/wall/roof. Using mobile phones and software programs to explore digital communication and how people experience their environment, designers like Dunne + Raby have radically abandoned traditional architectural concepts of space. These studies describe the relationships between physical and digital and the intermediate spaces in these relationships. Architecture creates its own work program before it is completely transformed into art, and begins to become "intelligent" and "cybernetic", like all natural products that can embrace and adapt to their environment and other perceptual elements. When designing Lars Spuybroek's Freshwater Pavilion and Kas Oosterhuis's Saltwater Pavilion, which are both multimedia exhibitions about water and pioneering buildings in this field, synthetic organisms were considered in order to close the huge gap between artificial and natural (Figs. 3 and 4).

The development of telecommunications and information technologies has triggered the global digital transition event, whose social, cultural and economic consequences further affect our information society. This is a scenario that requires considering the implications not only of the behavior of individuals, but also of the exchange of information (data) through intangible relationships (links) that form a "network society" (Castells, 1996). Recent innovations in machine learning technology, which can process a large amount of data today, have placed artificial intelligence (AI) at the center of discussions. Artificial intelligence has been defined as a "key activating technology" open to continuous learning, aiming to automate processes in the European institutional framework, suggesting suggestions, decisions and predictions to achieve selected goals (European Commission, 2020). It has already been discussed that artificial intelligence systems inspired by the operation of biological neural networks cannot be compared with "intelligence" (Crawford, 2021). However, the capabilities of machines (memory capacity and computational speed) are now indispensable to support the decision-making process in solving increasingly complex problems and show their potential for application in all industries, including construction.

In architecture, it is an expected result that the decision-making process is supported with new tools in the context of the ever-renewing needs of societies, the understanding of design, the definition and validity of design

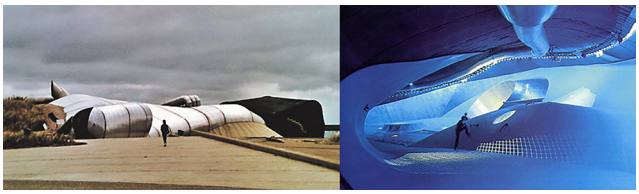


Fig. 3 Lars Spuybroek, Freshwater Pavilion, 1997 (adapted from Georgia Institute of Technology)

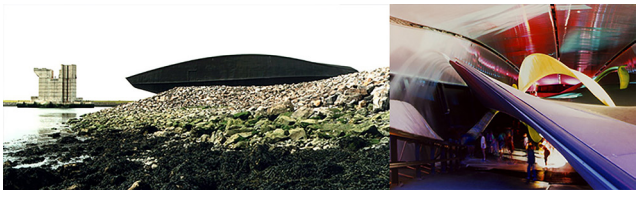


Fig. 4 Kas Oosterhuis, Saltwater Pavilion, 1997 (adapted from Oosterhuis)

in the context of increasing complexity (Ferrante, 2020). The field of architectural design, a number of "wicked" problems arise due to its unique multi-parameter, multi-scale and multidimensional characteristics (Rittel and Webber, 1973), is too vague and complex to accept unique solutions. Therefore, it is difficult to implement processes based on mathematical (algorithmic) thinking. In fact, artificial intelligence in architectural design is still in an embryonic stage (ECSO, 2021).

Today, work in this field describes the design activity as a "dual" model involving continuous and increasingly fluid transitions between two separate but complementary processes (Kelly and Gero, 2021). This scenario would define the not-so-clear, even fuzzy boundaries of competences between computer and human, and make the distinction between an "automatic" mechanism ("self-propelled") and an "autonomous" mechanism performing operations that produce results based on selected inputs. It is as in the case of AI, that is, a system (literally "having its own laws") that processes data and produces results without the direct intervention of the designer (Bernstein, 2022).

3 A productive and algorithmic system: Voronoi

When the designer adopts a productive approach in architectural design, he/she can adapt algorithmic systems to the design in a unique way, combine several algorithmic systems, and even write his/her own algorithm. On the other hand, productive, parametric and digital design concepts come into question when the algorithmic design method is chosen in architectural design (Çıltık, 2008).

Many generative design systems have been developed to use in the architectural design process. These systems range from a simple sequential algorithm to complex systems inspired by nature and algorithmic diagrams. According to Deleuze's definition of diagram, diagrams are abstract because they do not always have a physical counterpart in being likened to an abstract machine, but they are still machines with a holistic attitude (Deleuze, 1995). Like any system with a holistic attitude, diagrams are the result of the joint decisions of the smallest organized parts and the composition of the parts. It offers the designer the opportunity to express complex data in schematic and graphical language. Therefore, according to the designer's interpretation, diagrams are a productive tool that organizes the design process and method, as well as the design form, so that the data are components of an algorithmic system (Özdemir and Önal, 2016).

Diagrams turn into a way of thinking in the design process while reaching the design product. According to Eisenman (2010), at the end of the design process, diagrams also show the general attitude of productive systems, the attitude of reaching multiple alternative results at once. This attitude has a dominant effect on Eisenman's designs created by algorithms in the digital environment, where he processes data as an organic whole (Eisenman, 2010). Many designers have used the design process method, which leads to these unpredictable results in the digital environment with generative algorithmic diagrams. The algorithmic systematic setup that the diagrams present in the architectural design process has a priority over the design form. The holistic setup of the data included in the design process constitutes the main logic of the diagram. This diagram setup offers the designer the method to reach the design product. The algorithmic system of the diagram provides the ability to add, remove, replace, integrate, change, etc., update the integrated data in the design process when necessary (Özdemir and Önal, 2016).

In this study, Voronai diagram has been chosen/decided as the architectural production principle, which will be tested with artificial intelligence interfaces. Voronoi emerges as an algorithmic and productive system. In order to get efficient and meaningful results while generating the desired production from artificial intelligence bots, an algorithmic and productive diagram is given to these interfaces as a way of thinking, with the aim of reaching a multi-alternative result.

Voronoi was first used in 1644 by Descartes in his book Principles of Philosophy, when he depicted the stars in the solar system with convex polygons. In later periods, the concept of Voronoi was developed independently in different fields and was called by various names such as mid-axis transformation in biology, Wigner-Seitz field in chemistry, and Thiessen polygons in meteorology and geography (Öneş, 2011). Voronoi diagram began to be officially known as Dirichlet mosaic in 1850 when Dirichlet used this concept in mathematics, and later in 1908, when Georgy Voronoi used the diagram according to an algorithm, it was also called Voronoi tessellation, Voronoi clustering or Voronoi diagram (Coates, 2010).

Voronoi diagram is a type of decomposition that allows a certain set of separate points or set of multidimensional objects to be divided into sub-cells in an algorithmic order by defining them in metric space. In other words, it is a method of dividing the area or volume into defined

parts by analyzing the area or volume in line with the data, based on a starting area or volume. These cells are called Voronoi cells. Each point from the set of points or the set of objects is predetermined to form the core, and the other core points surrounding each core form a reference to the edges around that core (Friedrich, 2008).

Voronoi diagram consists of Voronoi cell, Voronoi node, Voronoi polygon and Voronoi area. Fig. 5 shows the main components of the Voronoi diagram (Park et al., 2008).

In 1934, Boris Delaunay discovered the triangular relationship in the Voronoi diagram and created the Delaunay triangulation method. This method is geometrically equivalent to the Voronoi diagram. Although directly related to Voronoi polygons, they visualize the set of reference points from the data in different ways. The triangles formed by connecting each point in the data reference points set with the two nearest neighboring points are called the "Delaunay triangle". Delaunay triangles are obtained by combining the centroids of the Voronoi polygons, and Voronoi polygons are obtained by combining the median perpendiculars of the triangles (Fig. 6) (Yanalak, 1991).

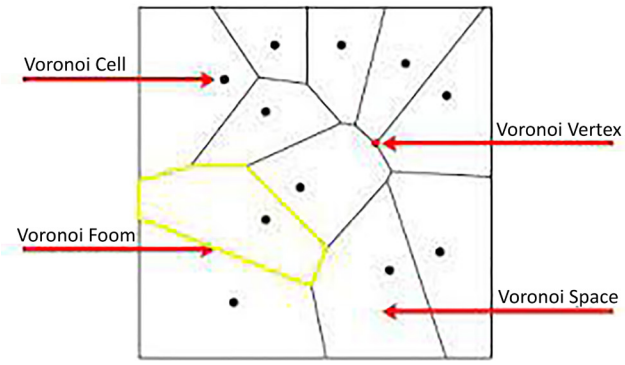
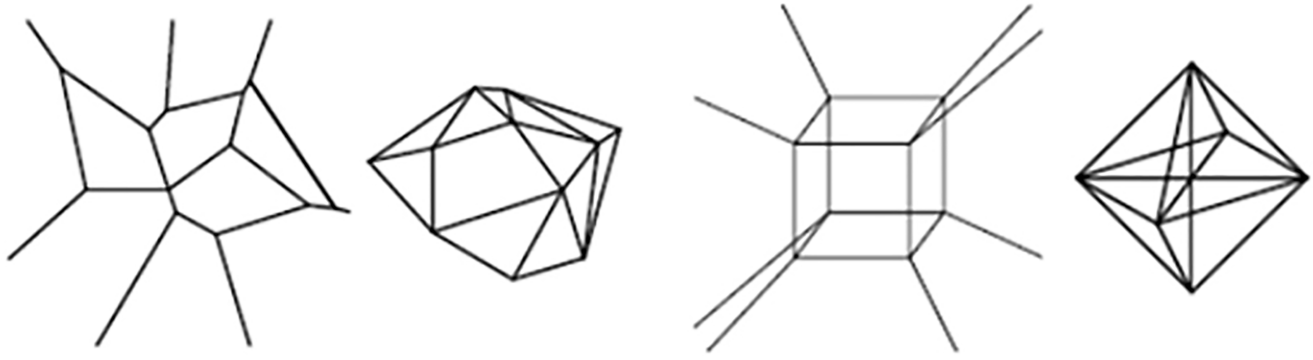


Fig. 5 Voronoi diagram components (adapted from Park et al. (2008))

Voronoi diagrams are generally calculated with "computational geometry" methods. In other words, a Voronoi diagram is a path pattern that consists of a number of points, using the least energy to switch cells from one to another (Coates, 2010). The fact that the Voronoi diagram shows a path pattern that optimizes the distance between Voronoi cells and provides transition with minimum energy explains the use of the Voronoi diagram and the Delaunay triangulation method directly related to the diagram in measurements, designs and investigations between points in different disciplines (Coates, 2010). Working together, these two systems provide all the information about the data points and the sub-Voronoi cells that are being parsed, as well as allowing for collective control of the points and cells. These geometric systems are used in many fields such as computer programming, topology optimization, map creation, structure and facade design in architecture, urban design, etc. (Friedrich, 2008). Voronoi diagram produces organizational methods for clustering multidimensional data in different dimensions (Park et al., 2008). It offers unique modular structures in geometric equivalence with the potential to use various complex geometries with its method (Friedrich, 2008). The ability to provide, cluster, define and manage these properties and parametric multidimensional relations explains the use of Voronoi diagram in different applications in architecture and urban design. Architects and designers can generate new cellular complex geometries with the creative potential of the Voronoi diagram (Friedrich, 2008).

The Voronoi diagram enables the generation and development of spatial forms that integrate all parts of a system with self-organization. Parts or data defined by integrating with self-organization gain the feature of ensuring the development of the whole by constantly multiplying



(a) (b)

Fig. 6 Voronoi diagram and Delaunay triangles, two-dimensional drawings (a), and three-dimensional drawings (b) of the same set of points (adapted from Fortune (1995))

with the Voronoi productive system. The generative-algorithmic structure of the Voronoi diagram, which includes a series of computational procedures, allows unlimited feedback, updating and optimization processes as well as the adaptation of the data in the design (Park et al., 2008).

With the use of digital methods in architecture, geometries in nature, including the Voronoi diagram, have begun to be used conceptually in architectural projects (Coates, 2010). The inclusion of Voronoi diagrams in architectural design brings with it the design and production of new and complex forms. The ICD/ITKE Research Pavilion built in Stuttgart in 2011 with Voronoi diagrams could be given as an example (Fig. 7).

4 Architectural production experiments with AI interfaces: Voronoi diagram

Although the concept of generative art has been discussed as a research area for years, it only entered the public perception with the emergence of publicly available diffusion model platforms (artificial intelligence bots) with text to image, image to image capabilities such as DALL-E, Midjourney or Craiyon. These artificial intelligence bots compete with each other not only in terms of technical such as skills, abilities or visual quality, but also in terms of user experience. Midjourney interacts directly with its community by sharing inquiries and products on public or private channels on the Discord app. On the other hand, DALL-E 2 is only accessible to users through a special interface with authoring and editing tools. Craiyon, the last tool of this study, formerly DALL-E mini, is an AI model that can product images from text prompts (Craiyon).

The internal model architecture and interface paradigm affect how these models can be used. Fig. 8 shows the similarities as well as the differences between DALL-E 2, Craiyon and Midjourney. Core blocks of technologies in gray are similar across technologies as noted earlier. The differences stern from the approaches of different AI interfaces, the workflows they provide with different capabilities.

In Fig. 8, while the basic workflow in gray is similar, it's clear that the ways to improve its results are drastically different. For now, only Midjourney offers cascade upscaling, and it does so in multiple different sizes. That's why Midjourney's workflows focus on creating and comparing image variants from different text-to-image models and then recommending the best one with limited possibilities to recompare the text prompt. In particular, it only takes

Fig. 7 ICD/ITKE Research Pavilion, 2011 (adapted from Arch daily)

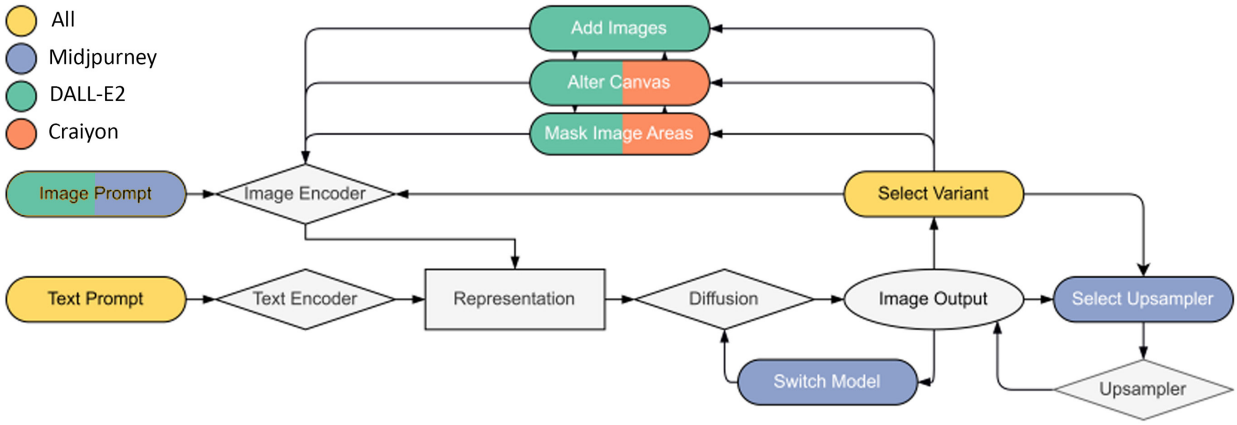


Fig. 8 Model architecture and image generation process in different models (adapted from Ploennigs and Berger (2022))

a few seconds to create images on all models, allowing creativity to be explored and designs to be fast (Ploennigs and Berger, 2022).

Given the discussed differences of the platforms (Table 1) in user interface and technology, they vary strongly in the architectural use cases that they support. To analyze this, in this study, architectural plan and form production experiments were carried out with the principle of "Voronoi" diagram, which is a productive and algorithmic system, through the text-based artificial intelligence interfaces Midjournej, DALL-E 2 and Craiyon. It is believed that the production of complex geometries with artificial intelligence will be a great development for the discipline of architecture. These interfaces are bots that provide very fast and autonomous results. The fact that it presents different alternatives together and very rapidly shows once again the importance of using technology as a tool for architecture. At this stage of the study, experiments were carried out both on the plan plane and on the basis of architectural form. The aim of this was to discuss how and how much artificial intelligence interfaces take place in architectural design and to identify their usage areas in terms of concept and practice. While using different artificial intelligence interfaces, the goal is to experience the skills of different bots and to question the stylistic differences, if any. In this way, a method proposal could be developed for future studies.

Table 1 Comparison of platforms with supported features:
● Support, ○ No support

Model	txt2img	Editing	Upscaling
Midjourney	●	○	●
DALL-E 2	●	○	○
Craiyon	●	○	○

The network diagram of the working parameters (Fig. 9) was prepared for the case study whereas the diagram study included the analysis of the disciplines of art, architecture and artificial intelligence and their relations. Generative systems under the discipline of generative art and architecture are also related. Again under the art discipline, digital art and generative art are also related to artificial intelligence. The interfaces of artificial intelligence, Midjourney, DALL-E 2 and Craiyon are also text-based bots. In this study, items such as "Voronoi diagram" in the parameters became the keyword input of these text-based bots.

All three interfaces used are text-based and visualize the given keywords. The first attempts were made in the Midjourney artificial intelligence interface. Midjourney is a bot application that runs on its own server inside the Discord platform. Bots are programs that display autonomous behavior that appear to be normal users, developed for the purpose of turning Discord into a more interactive environment (Verma et al., 2021). Midjourney interacts directly with its community by sharing queries and results in public or private channels on the Discord app.

The first keywords entered in Midjourney are for the production of architectural plans. Commands such as "an architectural plan with the principle of Voronoi diagram", "an architectural plan with Voronoi geometry" and "an architectural plan designed with Voronoi geometry" were used, and the results in Fig. 10 were reached.

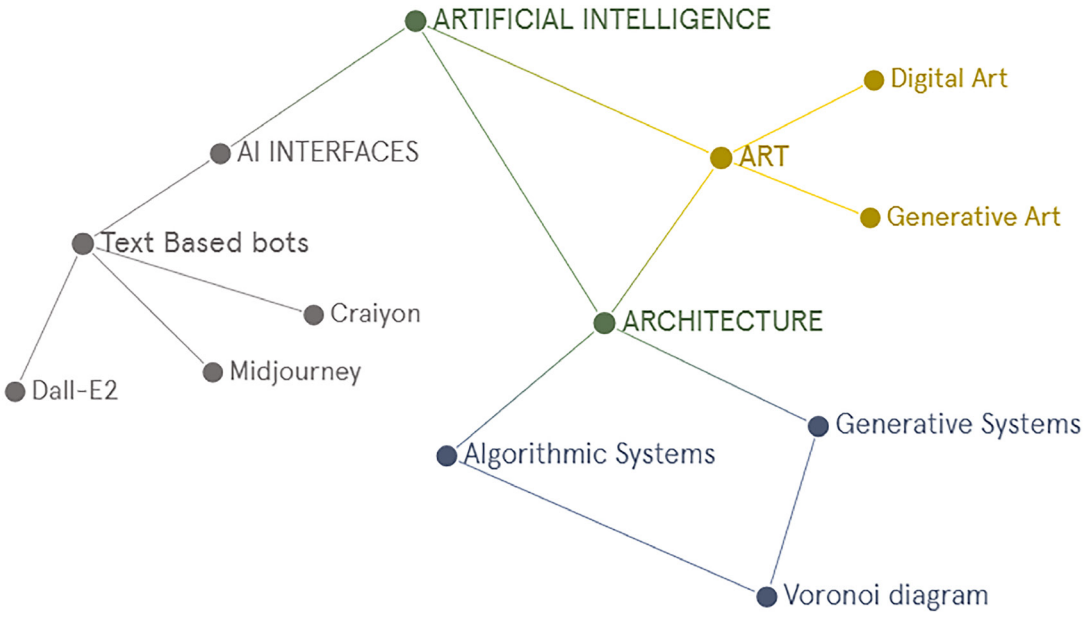


Fig. 9 Network diagram of study parameters

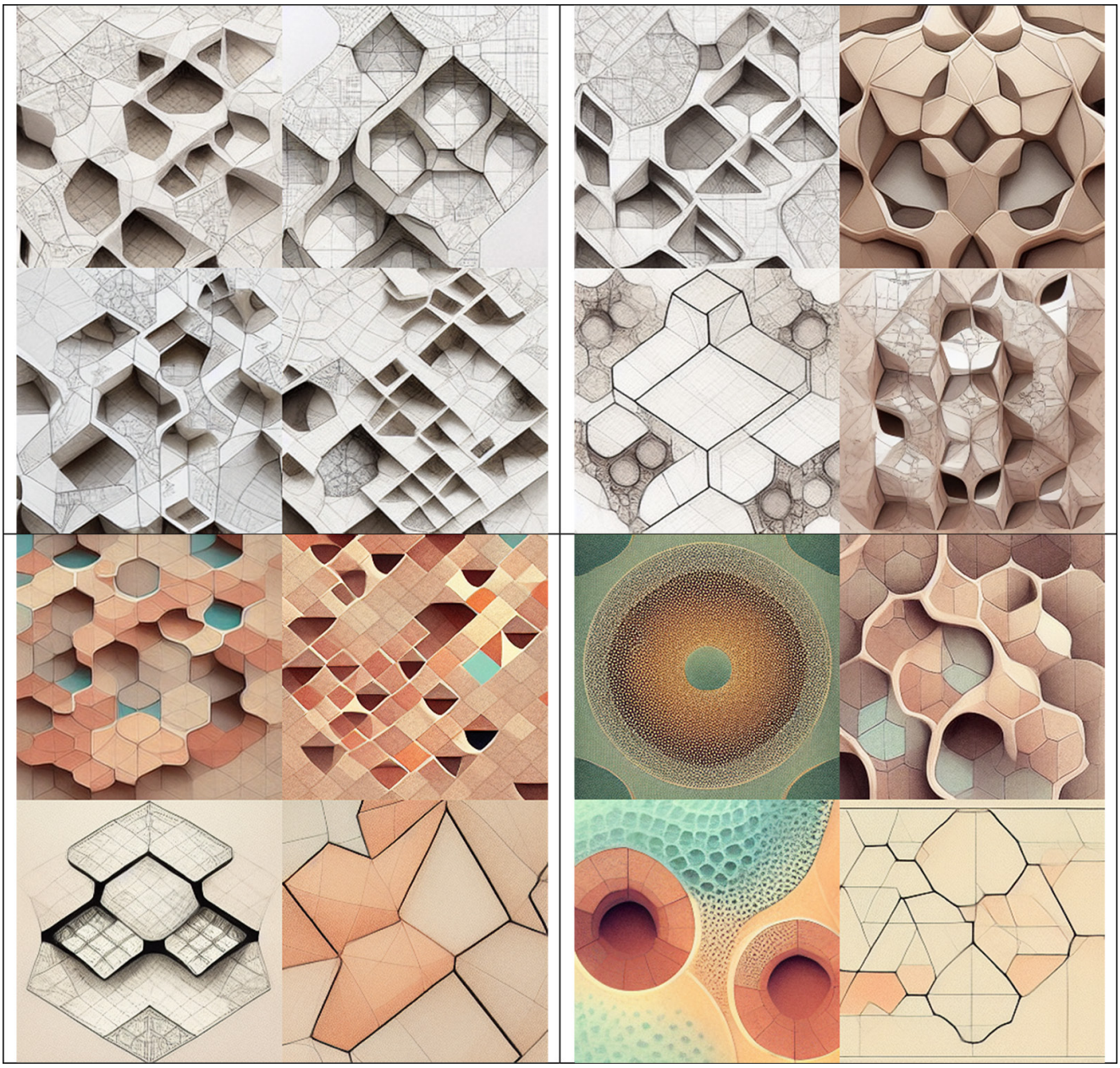


Fig. 10 Plan generation experiments with Voronoi diagram, Midjourney

A total of 16 results were obtained in the Midjourney artificial intelligence bot using the Voronoi diagram. These generated forms could be used for the concept stage of the design process and give an idea about the plan plane of architectural design, although one should keep in mind that the drawing of the geometries might not comply with the architectural plan standards. Additionally, Midjourney has the ability to give new alternatives to one of the four alternatives it has given, which could also be used for the plans. In overall, we can conclude that besides the architectural qualities of the results, their visual values (color, ratio, etc.) as well as their resolutions were found to be decent.

After the architectural plan production trials, keywords were written for the desired outputs after the "/imagine" command to produce architectural form in the same artificial intelligence interface. Commands entered with these keywords that contain descriptive features, in addition to commands containing architectural features such as "an architectural structure designed with the principle of Voronoi geometry", "an architectural building designed with the principle of Voronoi geometry", "an architectural structure produced with a Voronoi diagram", this time adjectives related to visual quality such as "hyper detailed", "hyper realistic" have also been added. Obtained results are shown in Fig. 11.

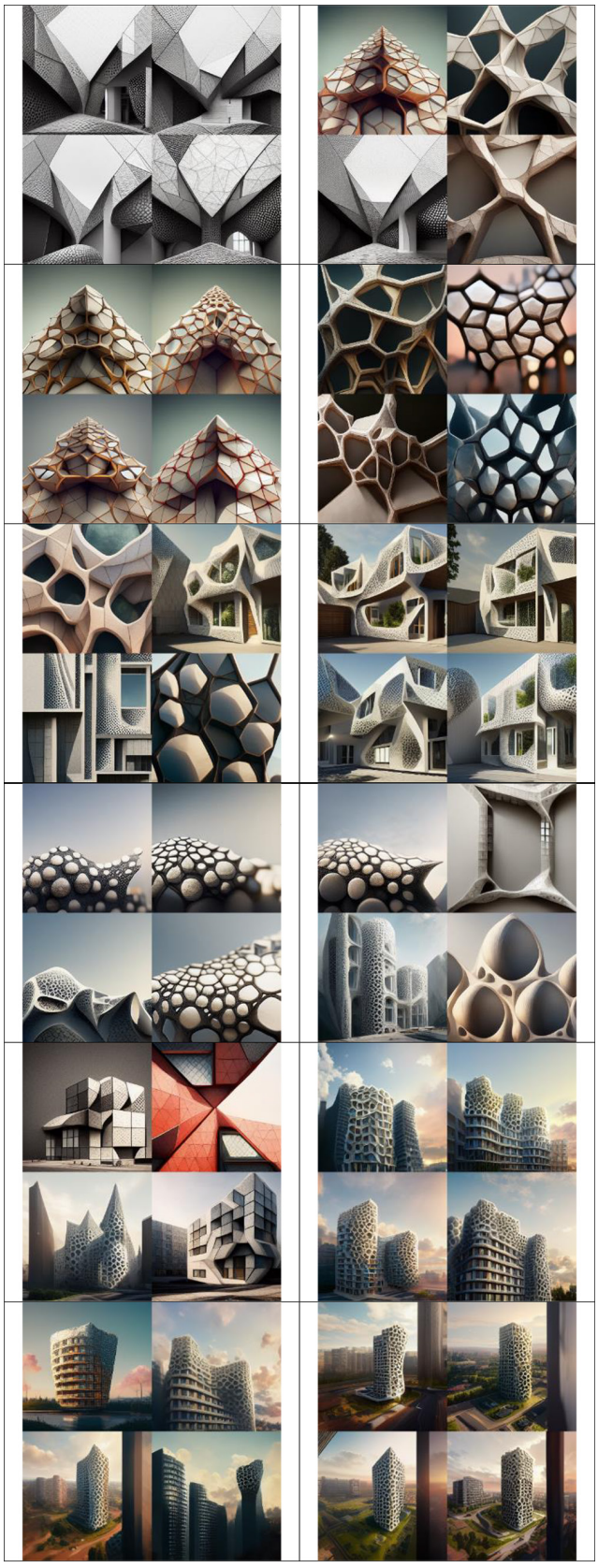


Fig. 11 Form generation experiments with Voronoi diagram, Midjourney

As a result of form generation experiments, a total of 48 different alternatives were obtained. These generated forms were entirely within the scope of the discipline of architecture, however, some of them were structures obtained from the Voronoi diagram, some of them were considered as architectural shells and some of them were the examples of facades. It can not be wrong to say that there are fractal representations of the Voronoi diagram for the end products. The fractal facades, structures and shells obtained from the Voronoi diagram raise the question of whether text-based architecture is a new method for architecture.

Midjourney interface also has the ability to output selected alternatives in higher resolution. In this way, higher resolution visual outputs of the selected images (Figs. 12 and 13) were obtained. When these are examined, one low-rise and one high-rise building facades and two architectural structures whose forms are obtained

Fig. 12 High resolution result product 1, Midjourney

Fig. 13 High resolution result product 2, Midjourney

from Voronoi geometry are seen, and at the same time, their aesthetic values are found to be high.

DALL-E 2 is created by OpenAI and is a successor of DALL-E. DALL-E 2 is another text-based artificial intelligence interface like Midjourney with similar working principles. By most, perhaps the most advanced version of the technology at the moment is DALL-E 2, which is based on the unClip method developed in it (Ramesh et al., 2022). An image encoder is mentioned that encodes both text and images into a diffusion-based common representation domain (previous). Rendering is done by a similarly trained decoder that converts the previous encoding into an image. Here, same keywords were entered into all artificial intelligence bots, in order to compare the results with the ones acquired using Midjourney. Differently, plans as well were attempted to generate on the DALL-E 2 ai interface (Fig. 14).

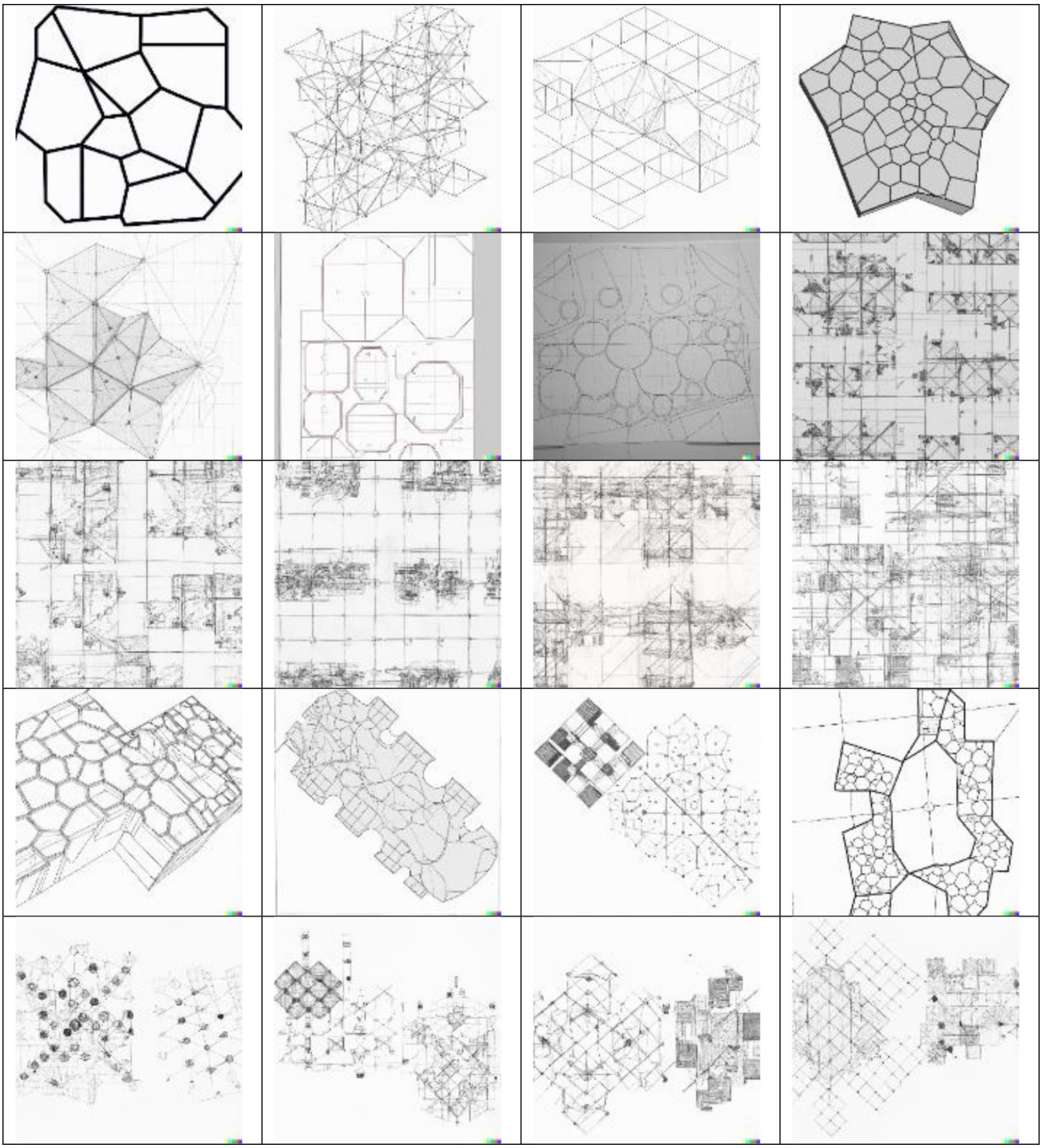


Fig. 14 Plan generation with DALL-E 2

In line with the keywords entered for the production of the plan, 20 different results were obtained with DALL-E 2. The results regarding style were found to be highly different than the ones obtained with Midjourney. It makes one think that these results, which are different alternatives that can be described as plan sketches at the preliminary design stage, can be used in concept studies. It is believed that it can be the first step of a new method for architectural design to transform complex geometries into plan schemes autonomously and quickly. DALL-E 2 generates 4 alternatives after the first commands, and when the visual product selected among them is continued with the "generate" command, new alternatives derived from the corresponding product are given. In this way, new productions could be produced towards the desired result in line with the ideas of the architect/designer.

After the plan trials, shape production trials were also obtained by entering commands such as "an architectural structure designed with the principle of Voronoi geometry", "an architectural building designed with the principle of Voronoi geometry", "an architectural structure produced with a Voronoi diagram" in the DALL-E 2 bot. Although keywords such as structure and form were given in this interface, only sections from the structure or facades were taken as visual output. The results were satisfying in terms of resolution and visual quality, however, no significant results were obtained related to the architectural form (Fig. 15).

The last tool of the study is the artificial intelligence interface Craiyon. Craiyon, like other interfaces, is word-based and provides autonomous, fast alternatives. It responds to each text with nine different alternatives and it does not allow to select one of them and reproduce it as in other bots. Finally, the resolution appears to be too low when the images are printed out one by one.

As a result of the keywords entered for the plan production experiments, 36 alternatives were obtained (Fig. 16). These alternatives were the transformations of the Voronoi diagram into two-dimensional different geometries which could be used conceptually in architecture, at least to give an idea. Still, it is not likely to talk about an adequate architectural plan, instead, it can be evaluated as a plan scheme.

A total of 72 different alternatives were obtained from the form production experiments with the Craiyon artificial intelligence interface. In the light of the fact that only four of them gave a result such as two-dimensional structure drawings, it would not be wrong to state that the other result products were architectural forms/structures

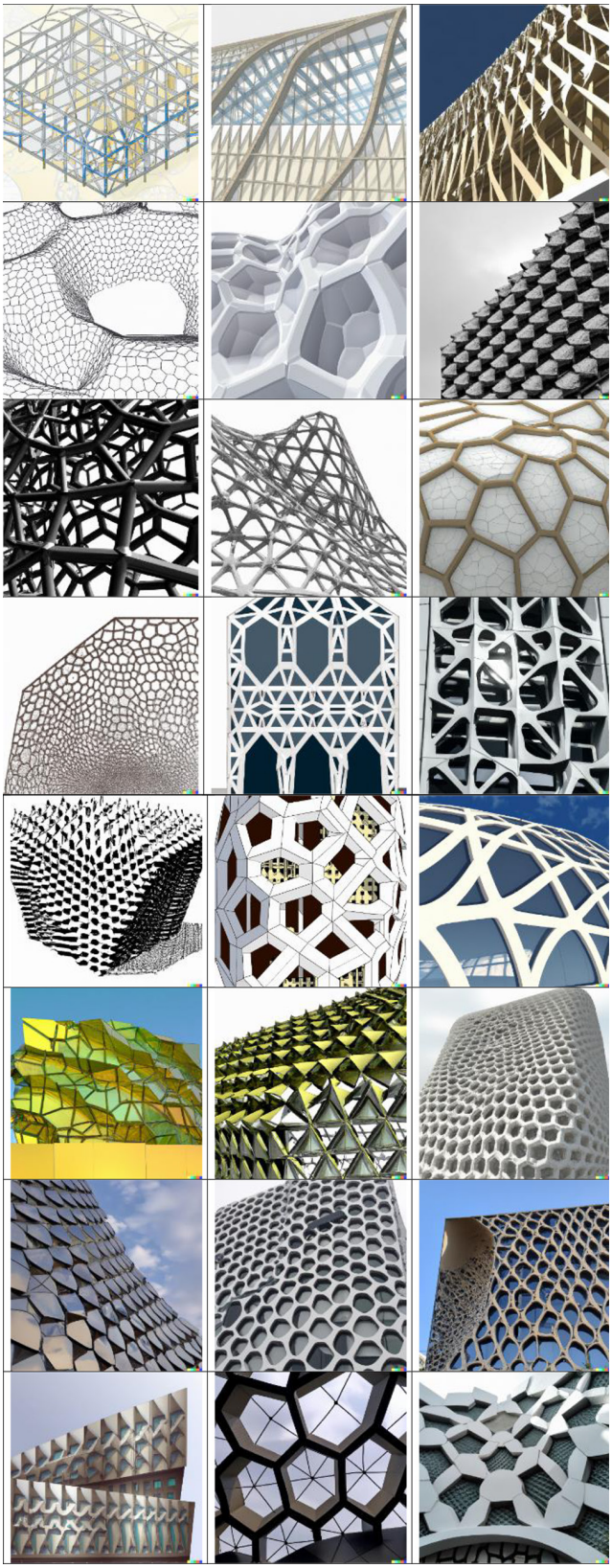


Fig. 15 Form generation with DALL-E 2

produced with the principle of Voronoi diagram. In future, a new era can be envisaged with the developments of methods that accelerate the decision-making processes of

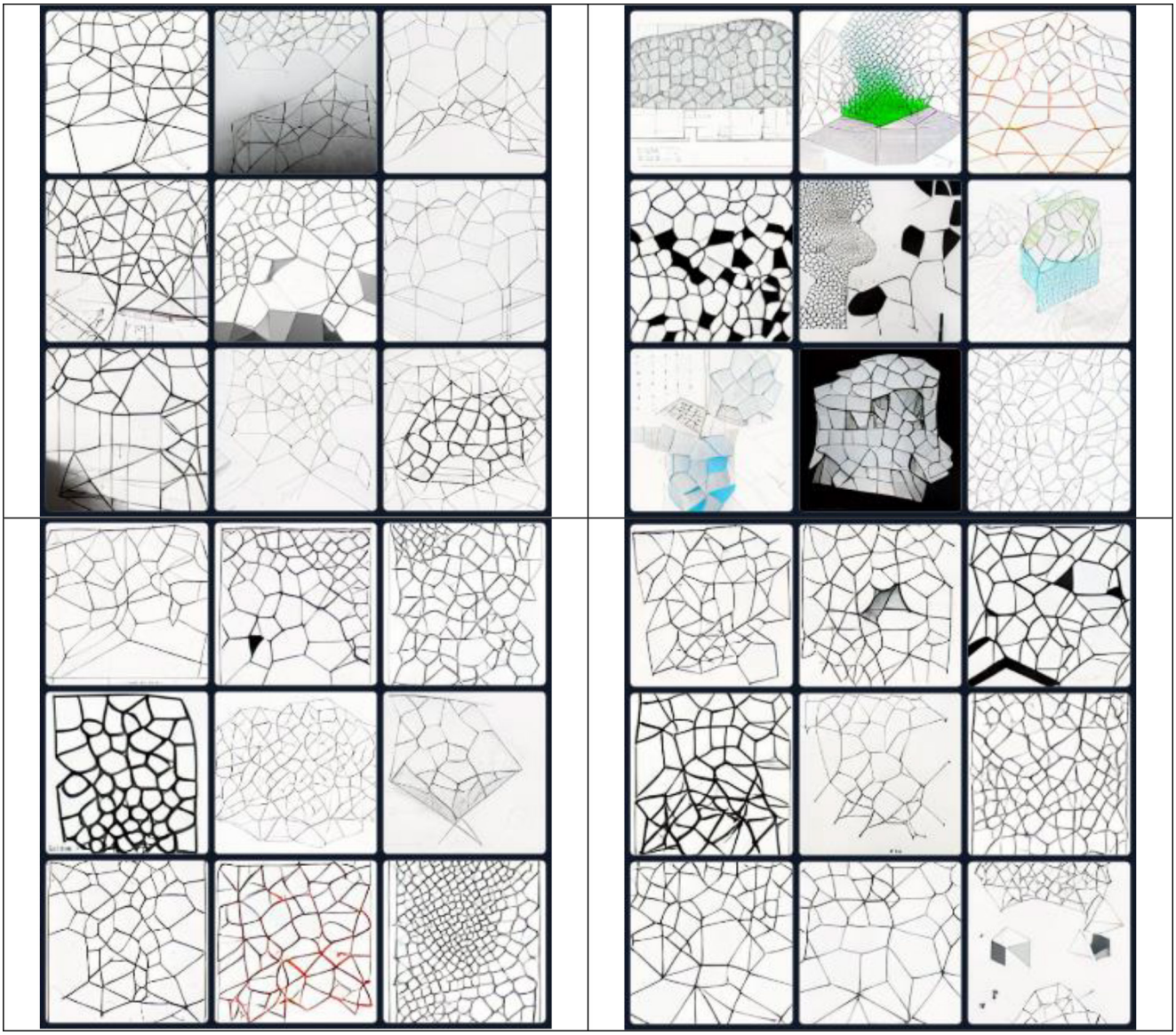


Fig. 16 Plan generation experiments with Voronoi diagram, Craiyon

the architect/designer for mass design studies using the 3D printouts of these results. It is highly possible to mention not only visual art but also architectural results as the alternatives are examined in Fig. 17.

The production of architectural plans and forms, with multiple alternatives, has been the problem of the discipline of architecture since the past. This search continues today. This study emerged as a result of this search. Unlike the methods in the past, the artificial intelligence interfaces used in this study are considered as a design input rather than an architectural production method like a drawing tool.

When the products that are the result of the experiments are examined, the plans and architectural forms that are aesthetically good can also be described as architectural presentation quality. But it is also more than that. These results, produced in the form of multiple alternatives, make sense when examined in the context of the discipline of architecture, although they differ in style at each interface. The skills and visual qualities of the interfaces used are given in the Table 2 in the context of the results.

A method has been tried in the discipline of architecture with the use of digital art tools, and it has been successful even in its infancy. As these AI interfaces will be developed, these methods will also be studied and developed. In this context, the boundaries between different disciplines such as art, architecture and artificial intelligence are becoming abstract.

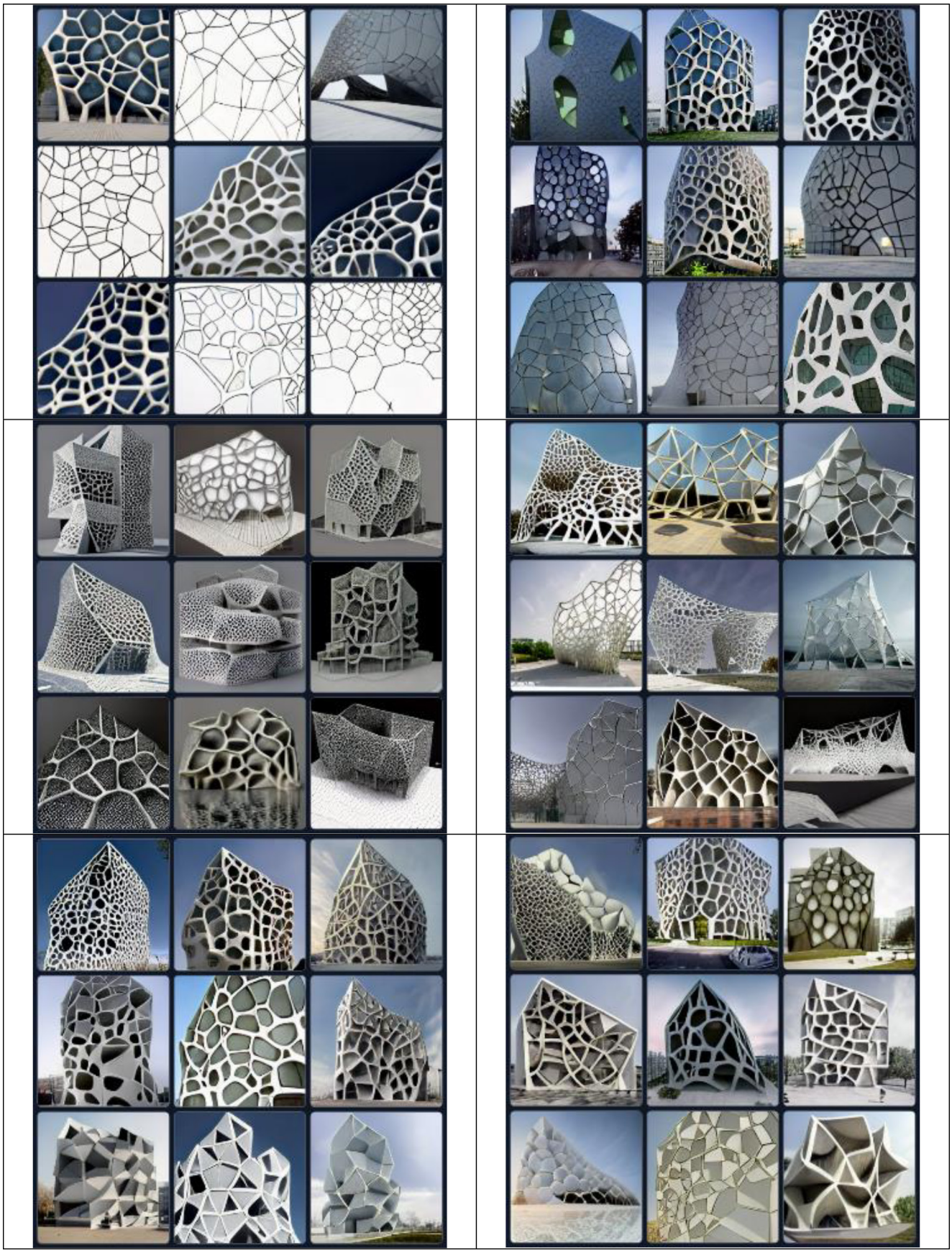


Fig. 17 Form generation experiments with Voronoi diagram, Craiyon

Table 2 The skills and visual qualities of the interfaces:
✓ Full, ● Limited, ○ Bad

Model	Plan-Sketch	Architectural Plan	Structure	Architectural Building	Visual Quality
Midjourney	●	○	●	✓	✓
DALL-E 2	✓	●	●	●	●
Craiyon	●	○	●	✓	○

5 Conclusion

Digital technologies, the scope of which are increasing, are fed by the combination of different disciplines. As a result, there is an intertwined change between roles, and the sharp boundaries of disciplines gradually lose their clarity.

The change and digital transformation in the field of art also showed its effect in the field of architecture, and the new concepts that emerged with this process brought up some discussions in the world of architecture. These discussions are shaped by the concepts of "new user profile" and "new space" created as the architectural equivalent of new art themes that emerged with the integration of digital technologies into the field of art. As a result of these discussions, many concepts such as artificial intelligence, virtuality, virtual architecture, cyber architecture, interactive architecture have entered the architecture discipline. Boundaries that could not be crossed before, experiences that could not be lived have created new expression techniques and a new aesthetic understanding in architecture. With this study, it is aimed to create a conceptual discussion environment for the effects of developing technology and digital/productive art concepts on architecture, common design methods that may occur between these disciplines, and new aesthetic searches.

The relationship between "virtual" and "real" is important in emerging new space experiments. With the formation of this experimental ground, a relationship between the virtual and the physical began to take shape. Instead of looking at the virtual as the opposite of reality, it would be more appropriate to look at it as a separate layer of reality. In this case, the concept of virtual emerges as a new way to understand and comprehend physical reality (Purves, 2005).

Ensuring the development of new technologies in line with our goals, guiding, accompanying and even guiding change in an active and proactive context will be more necessary than ever in the foreseeable future. In architecture, this means setting criteria for improving processes in design practice, while structuring information to digitize it (Russo Ermolli, 2020).

In the architectural design process, design methods are also redefined by breaking away from traditional design processes and using the computer as a design input and a new database system for shaping works rather than a drawing tool. Architectural spaces, where the importance of the user and various contextual factors are gradually increasing in their formation, are transformed into interactive environments by giving the user the opportunity to "reshape" thanks to these databases. In this study, artificial intelligence interfaces, together with computer developments, are considered as a design input. This article looks at artificial intelligence and art/design creation tools to provide a snapshot of the current situation and discuss their applicability in architectural practice. For the concept design, which is the stage of starting the architectural design, the use cases that are already possible were determined with the rendering bots. The similarities and differences between the three existing AI interfaces selected were highlighted. Experiments were made on artificial intelligence bots, which is an interactive environment that is considered as an architectural design method rather than an architectural presentation technique, and multiple alternatives were obtained as visual outputs autonomously and quickly. According to the evaluations, it is foreseen that this method can be used and improved in design with the support of the final products that can be considered as inputs for the pre-design phase. With the development of this method, new relations of these disciplines for the future will be defined and the use of the undeniable power of these new formations will be examined.

It is seen that developing digital technologies, computer environment and new art themes are an important source that opens new horizons in architectural concepts and reflects its own logic to architectural inputs and products. Artificial intelligence, cyberspace, abstraction, concretization and contextual design researches that emerged with the concept of digital art lead digital design towards the concept of interactivity, which describes the relationship process between the computer and the user. As a result, the user transforms into an interface, while the designer designs a set of relations. It is foreseen that the capabilities of these models and platforms will develop rapidly and new competitors will emerge in the future. A current trend is for workflows and capabilities between these AI interfaces to become similar as appropriate interaction paradigms are established.

This new "contextual design" agenda of interactive arts, interactive design and interactive architecture not only generates personal metaphors, but also creates new

systems and environments where there is a real-time flow of information. Interactive architecture is turning into a hybrid discipline with the ever-evolving technologies. Being aware of this transformation as architects, it should be emphasized that architecture is not only a visual art, but also the product of chaotic decision-making processes, and the transformation of the identity of the architect should be done with this control and awareness.

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