

Eleven Exercises in the Art of Augmented Design: Reflections on the Instrumentality of Generative AI in Navigating the Open-Closed Spectrum of Architectural Drawing.

by
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Author’s Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

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Abstract

This thesis, inspired by Marco Frascari's eleven exercises¹, explores the instrumentality of image-based generative AI in the context of architectural drawing. As image-based generative AI tools gain popularity, this research explores a series of 11 exercises translated from Frascari's work into the age of generative AI.

Primary research questions:

RQ1: What is the historical and contemporary role of architectural drawing in education and practice?

RQ2: How does generative AI disrupt traditional architectural drawing processes?

RQ:3 How can generative AI be instrumentalized to empower architects?

To address these questions, this thesis proposes and applies the **Open-Closed Drawing Framework**, which positions architectural drawings on a continuum from open, ambiguous sketches to closed, precise drawings. This framework is instrumental in understanding the varying degrees of ambiguity and precision in architectural representations and their potential augmentation through AI collaboration.

A key component of this research is the development of a set of eleven exercises for engaging with generative AI in the production of architectural drawings. By beginning with Marco Frascari's eleven exercises, and adapting them to engage with image-based generative AI, the translation between the two becomes an exciting challenge in its own right, underscoring the differences between traditional and generative creative processes.

These eleven, translated exercises lean on the **Open-Closed Drawing Framework** to organize architectural drawings in relation to each other.

¹ Marco Frascari's eleven exercises in the art of architectural drawing explores the intricate relationship between drawing and architectural thought, emphasizing drawing as a critical, imaginative, and interpretive act integral to the design process through a series of practical exercises.
Marco Frascari, *Eleven Exercises in the Art of Architectural Drawing: Slow Food for the Architect's Imagination* (London ; Routledge, 2011).

By providing a structured framework and exploring a series of exercises, the thesis contributes to the ongoing discourse on AI's role in architectural drawing. It offers a nuanced perspective that views generative AI as a catalyst for innovation rather than a substitute for human creativity. This research invites architects to engage with the future of architectural drawing through a series of exercises exploring image-based generative AI.

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The Structure of This Thesis

In Marco Frascari's seminal book, *Eleven Exercises in the Art of Architectural Drawing: Slow Food for the Architect's Imagination*, he emphasizes the cognitive and imaginative aspects of drawing, positioning it as essential to architectural thinking. This work extends Frascari's methodology into a more contemporary context by incorporating AI into the drawing process. The proposed Open-Closed Drawing Continuum framework builds on Frascari's ideas, categorizing architectural drawings on a spectrum from open, ambiguous sketches to closed, precise drawings. This framework is key to understanding AI's ability to enhance various stages of the design process, adding value to both ambiguity and precision in architectural representations.

The first research question – what is the historical and contemporary role of architectural drawing in education and practice – begins with a comprehensive literature review. This review examines the historical significance and contemporary application of architectural drawing, tracing the evolution from traditional hand-drawn techniques to modern digital practices. It explores how drawing fosters cognitive and creative skills in students, serving as a method of thinking and exploration. The review also highlights drawing's crucial role in professional practice, emphasizing its importance in conceptualizing, developing, and communicating architectural ideas. Architectural drawing remains essential, connecting abstract concepts with tangible designs. Understanding its role in both educational and professional contexts is essential to exploring its transformation in the age of AI can be properly explored.

The second research question – how does generative AI disrupt traditional architectural drawing processes – is addressed through theoretical analysis and empirical case studies. The thesis examines how generative AI alters drawing workflows, from initial sketches to detailed designs. AI introduces new possibilities and challenges, reshaping the design process. AI can automate aspects of drawing, allowing architects to focus on creative tasks, but it also raises concerns about authorship and originality. These tensions are explored to offer a nuanced perspective on integrating AI into architectural practice.

The third research question – how can generative AI be instrumentalized to empower architects – is explored through eleven practical exercises inspired by Frascari's work. Each exercise integrates AI tools with traditional drawing techniques, demonstrating AI's potential to augment human creativity and enhance design outcomes. These exercises provide a hands-on way to engage with AI, illustrating how it can support architects by enhancing both creativity and efficiency.

The central argument posits that AI in architectural drawing is a powerful augmentation to the architect's toolkit. Rather than threatening jobs or creativity, AI can be a collaborator, expanding design possibilities. This work contributes to the discourse on AI's role in architecture, viewing generative AI as an enabler of innovation. This Architects and Designers are invited to reimagine the future of architectural drawing in an era where intelligent machines are becoming increasingly common. This research bridges traditional drawing methodologies with AI technologies, preserving the rich tradition of architectural drawing while pushing it into a new era of innovation.

A Note on Drawing in This Thesis

As someone who has intimately identified with hand drawing for my entire life, and the reasoning for pursuing an education in architecture, the decision to exclude images from this thesis is both deliberate and conceptually grounded. While architectural drawings have traditionally been central to the practice, the absence of images in this work serves as a critical reflection on the changing role of drawings in design processes augmented by generative AI.

Historically, architectural drawings were seen as complete and static objects, serving as definitive representations of buildings or ideas. However, with the advent of AI tools, the role of drawings has shifted. This thesis examines how AI alters the creation and interpretation of drawings, positioning them as part of a continuum of open-ended processes rather than final, fixed outcomes. By intentionally omitting images, the text underscores a key argument: in an AI-augmented design process, drawings are not singular or complete but are instead evolving, fluid, and often ambiguous. Including static images could inadvertently reinforce outdated assumptions about their closed, prescriptive nature.

The absence of drawings also serves to emphasize the importance of active engagement with the drawing process itself – an approach central to the thesis. Instead of passively consuming images, the reader is invited to participate in the production and exploration of architectural representations through the exercises proposed in this work. These exercises – such as creating hybrid AI-generated images and layering them with traditional techniques – are designed to provoke thought, experimentation, and personal involvement with the continuum between open and closed drawings. This participatory framework situates the reader as an active co-creator, allowing them to experience the dynamic, iterative nature of drawing in the AI age.

By choosing not to include predefined images, this thesis shifts the focus from drawings as finished objects to drawings as processes of exploration and generation. The exercises within the thesis serve as a bridge for readers to directly engage with the ideas being discussed, encouraging a tactile, embodied interaction with drawing that cannot be conveyed through mere

illustrations. Through these exercises, participants can explore the ambiguity of the open-ended sketches and the clarity of more defined representations, actively negotiating the boundary between human intuition and AI's generative capabilities.

In this way, the thesis underscores its argument that, in the context of generative AI, the act of drawing becomes an ongoing dialogue between the designer and the tools at their disposal. The decision to exclude static drawings supports this conceptual position by encouraging readers to embrace the process of drawing themselves, moving beyond passive consumption to become active participants in the evolving practice of design representation.

Post I On Drawing and Architecture

RQ1: What is the historical and contemporary role of architectural drawing in education and practice?

The History of Architectural Drawing

The evolution of architectural drawing practices from the Renaissance to the present day presents a captivating narrative of how technological advancements have continually redefined the role of representation in architecture. This journey begins in the Renaissance, a period marked by profound shifts in how architects conceived and communicated their designs. During this time, pioneers like Filippo Brunelleschi introduced linear perspective, a revolutionary technique that enabled architects to depict three-dimensional spaces on a two-dimensional plane with unprecedented accuracy.¹ This breakthrough allowed architects to communicate their designs more effectively and laid the groundwork for the professionalization of architecture as a discipline distinct from the building trades.²

During the 18th century, architectural representation continued to evolve, spurred by advances in printing technology and the proliferation of architectural treatises. This era saw the rise of the “paper architect,” exemplified by figures like Étienne-Louis Boullée, a 18th century French architect known for his evocative drawings that explored visionary concepts free from the constraints of construction. Boullée’s work, such as his Cenotaph for Newton (1784), utilized atmospheric perspective and dramatic lighting to convey sublime geometric forms, showcasing the visionary potential of architectural drawing.³ These speculative designs, while often impossible, expanded the boundaries of architectural imagination and influenced future generations of architects while increasing the value of representation as a whole.

Giovanni Battista Piranesi, an 18th-century Italian artist, architect, and engraver, is renowned for his imaginative and dramatic depictions of architecture. Unlike Boullée, whose work often focused on monumental forms and abstract ideals, Piranesi’s etchings explore the darker, more complex side of architectural imagination. Piranesi’s *Carceri d’invenzione*, a series of etchings describing imaginary ‘prisons’, painstakingly

¹ Samuel Y. Edgerton, *The Mirror, the Window, and the Telescope: How Renaissance Linear Perspective Changed Our Vision of the Universe*, First Edition (Ithaca: Cornell University Press, 2009).

² Robin Evans, *Translations from Drawing to Building*, AA Documents 2 (Cambridge, Mass: MIT Press, 1997).

³ Alberto Pérez Gómez, *Architectural Representation and the Perspective Hinge* (Cambridge, Mass: MIT Press, 1997).

assembled out of architectural fragments to create images of imaginary places, are among some of the most well-known examples of imaginary architecture.⁴ These images combine elements of the real and the fantastical, challenging conventional perspectives and evoking a sense of disorientation and wonder. Piranesi’s visionary approach to architectural drawing, much like Boullée’s, pushes the boundaries of what architecture could represent, suggesting a world where the physical and the psychological intertwine.

The 19th and early 20th centuries witnessed a remarkable diversification of representational techniques. From the precise renderings characteristic of Beaux-Arts training to the dynamic abstractions of modernist movements like Constructivism and De Stijl, architects continually sought new ways to depict and conceptualize space. This period was also marked by the advent of mass media and technologies such as photography and film, which opened up new possibilities for architectural representation to reach broader audiences and shape popular perceptions of the built environment.⁵

In the post-war era, the architectural discourse was further enriched by the megastructure movement and avant-garde groups like Archigram and Superstudio. These groups employed collage, pop art, and other innovative representational strategies to envision radical urban futures, often in response to the perceived shortcomings of modernist city planning.⁶ Archigram’s *Plug-In City* (1964), for instance, proposed a constantly evolving urban landscape shaped by prefabricated modules and consumer choice, reflecting the social and technological flux of 1960s Britain.⁷ These speculative projects, while rarely built, had a profound influence on architectural discourse and continue to resonate in contemporary conversations around smart cities, parametric design, and other emerging urban paradigms.

The digital revolution of the late 20th and early 21st centuries once again transformed architectural representation. Digital tools such as Building Information Modeling (BIM), 3D modeling,

⁴ Giovanni Battista Piranesi, *Piranesi* (London: Bloomsbury Books, 1988), 11.

⁵ Peter Cook and Archigram, *Archigram*, Rev. ed. (New York: Princeton Architectural Press, 1999).

⁶ Cook and Archigram.

⁷ Peter Cook and Archigram, *Archigram*, Rev. ed. (New York: Princeton Architectural Press, 1999).

and immersive reality have enabled unprecedented precision, coordination, and realism in architectural visualization. However, these advancements also raise critical questions about authorship, materiality, and the relationship between the virtual and the real in architectural design.

As we look to the future, it is evident that architectural representation will continue to evolve in tandem with technological change. The challenges of the 21st century, from climate change to rapid urbanization, necessitate innovative approaches to envisioning and debating possible futures. Speculative architectural drawing remains a vital tool in this endeavor, allowing architects to explore and communicate new ideas and solutions.⁸

The history of architectural drawing is a testament to the enduring interplay between technology and representation. From the linear perspective of the Renaissance to the digital tools of today, each era has brought new techniques and paradigms that have shaped not only how architects design but also how society envisions the built environment. This rich legacy underscores the importance of architectural representation as both a reflective and transformative practice, continually adapting to meet the needs and challenges of its time.

⁸ Nick Dunn, "Urban Imaginaries and the Palimpsest of the Future," in *The Routledge Companion to Urban Imaginaries*, 1st ed. (Routledge, 2019), 373–86, <https://doi.org/10.4324/9781315163956-28>.

Drawing and its Relation to Architecture

The Oxford English Dictionary defines architecture as “the art or practice of designing and constructing buildings”.⁹ Notably, this definition does not explicitly mention drawing, an omission that belies the critical role of drawing in the architectural process. A more nuanced understanding of architecture recognizes drawing as an essential component, serving as the primary medium through which architects conceptualize, communicate, and refine their ideas.

Robin Evans, in his seminal essay *Translations from Drawing to Building*, articulates that “drawing is not only a means to an end but a critical part of the architectural process itself.”¹⁰ Drawings act as the intermediary between abstract ideas and tangible structures, translating conceptual visions into detailed plans that can be executed in the physical world. They serve as both a creative and technical tool, allowing architects to explore spatial relationships, material qualities, and structural possibilities before any physical construction begins.

The centrality of drawing in architecture is further emphasized by Alberto Pérez-Gómez and Louise Pelletier in their work, *Architectural Representation and the Perspective Hinge*, where they argue that “architectural drawing is a complex and multifaceted practice that mediates between the realms of imagination and material reality.”¹¹ This perspective underscores the dual role of drawing as both an artistic expression and a technical necessity, highlighting its indispensable place in the architectural profession.

While the dictionary definition of architecture may overlook the importance of drawing, a more comprehensive view reveals that drawing is integral to the discipline. It is through drawing that architects translate abstract ideas into concrete realities, making it a fundamental aspect of architectural practice.

⁹ “Architecture | Oxford English Dictionary,” accessed May 28, 2024, https://www.oed.com/dictionary/architecture_n.

¹⁰ Evans, *Translations from Drawing to Building*, 156.

¹¹ Pérez Gómez, *Architectural Representation and the Perspective Hinge*, 47.

Drawing Methodologies

Architectural drawing is a fundamental aspect of the design process, connecting conceptual ideas with physical structures. Understanding various drawing methodologies and representational tools is key, especially in the age of AI, which will be discussed in the following section.

For the purposes of this work, architectural drawings can be categorized into projections, abstractions, and explorations. Paul Laseau, an architect, educator, and author renowned for his expertise in visual thinking and sketching techniques, particularly in using freehand sketching to develop ideas and communicate in the design process, elegantly summarized these categories in his book *Architectural Drawing: Options for Design*. His framework provides the foundational model for organizing architectural drawings in this research.

Projections – Orthographic Projections, Paraline Projections, Perspective Projections – are the foundation of the language of architecture as a practical art. Critically, the rules and standards of **Architectural Projections** allow “us to understand someone else’s drawings, or at least to begin to organize in our mind what is being communicated.”¹² **According to Laseau**, “The role of drawing conventions could be compared to that of the conventions for courses in a meal, in that they provide a broad framework and basic categorization within which one can explore and invent numerous variations in type or media.”¹³

Abstractions simplify complex ideas into essential forms, focusing on relationships and organizing principles without getting lost in specifics. These are especially valuable in the early design stages, allowing architects to explore spatial concepts without being restricted by technical details.

Explorations encompass experimental forms of drawing that prioritize investigation and creativity over technical accuracy. These sketches and speculative drawings push the boundaries of conventional representation, allowing architects to freely experiment with ideas.

These categories – projections, abstractions, and explorations – provide a framework for understanding different types of

¹² Paul Laseau, *Architectural Drawing: Options for Design*, 1st ed.- (New York: Design Press, 1991), 25.

¹³ Laseau, 25.

architectural drawings. However, the technological layer is essential to understanding how these drawing practices have evolved over time. From hand-drawn sketches to modern CAD and BIM tools, architectural drawing has always been shaped by the instruments available to the architect.

The Instrumentality of Architectural Drawing

Architectural drawing has always been more than a means of representation; it serves as a key instrument in the design process, shaping how architects conceptualize, explore, and communicate their ideas. Over time, the methods and tools used in drawing have evolved, with each technological shift bringing new possibilities but also altering the relationship between the architect and their work. This evolving **instrumentality** – the way tools mediate and influence the creative process – is crucial to understanding architectural drawing both historically and in the context of contemporary technologies such as AI.

Sketches have traditionally played a vital role in the early stages of design, enabling architects to engage directly with their ideas in a way that fosters creativity and discovery. As Daniel Herbert explains in *Architectural Study Drawings*, study drawings often occupy only a small fraction of an architect's time, yet they are essential to the ideation process.¹⁴ These drawings are personal and inward-focused, allowing architects to explore the core of their design concepts free from the technical and formal constraints that later drawings demand.

Herbert's observation of this misalignment between the importance of study drawings and the amount of time allocated to them reflects a deeper tension in architectural practice: as technology advances, architects are increasingly focused on presentation and construction outputs, potentially at the expense of the open, exploratory phases. This imbalance underscores the need for frameworks like the Open-Closed Drawing Continuum, which recognizes the value of early-stage, open-ended sketches in the creative process. Herbert critiques the insufficient theoretical basis for study drawings compared to more codified forms of architectural drawing, suggesting a need for more robust academic frameworks that could underpin their use and significance in the design process.¹⁵ Through this lens, sketches can be seen as tools that facilitate free, intuitive exploration – a form of cognitive engagement that may be constrained by the precision and efficiency of digital tools.

Juhani Pallasmaa's phenomenological approach further deepens the understanding of sketching as an instrumental

¹⁴ Daniel M. Herbert, *Architectural Study Drawings* (New York: Van Nostrand Reinhold, 1993), II.

¹⁵ Herbert, 13.

act, emphasizing the sensory and tactile engagement involved in hand drawing. Pallasmaa argues that the hand is not just a tool for executing the mind's ideas but is integral to the very formation of those ideas. His view of the hand as a cognitive extension highlights the sensory richness that drawing brings to architectural thinking. The physical act of sketching engages the body and mind in a way that fosters deeper connections to the design, a process that can be diminished by digital methods which prioritize vision over touch.¹⁶ He argues that the tactile qualities of materials and the scale of architecture can only be fully understood through the physical act of drawing, which engages the body and mind in a dialogue that is absent in computer-generated imagery.¹⁷

As technology continues to evolve, the nature of architectural drawing has shifted from hand-drafted sketches to digital tools like Computer-Aided Design (CAD) and Building Information Modeling (BIM). These tools have brought significant improvements in efficiency, accuracy, and collaboration, but they have also redefined the relationship between the architect and the medium. Where hand sketches allow for a fluid, sensory-rich interaction with the design, CAD and BIM prioritize technical precision and coordination, often favoring clarity and finality over ambiguity and exploration.

This shift in the instrumentality of drawing – from a tactile, sensory process to a highly precise digital one – illustrates how technology affects both the form and the function of architectural representation. The immediacy of hand drawing, where ideas emerge through direct interaction with the medium, contrasts with the detached nature of digital drawing, where the architect interfaces with a computer screen rather than the material world. Pallasmaa critiques this “false precision” of digital imagery, arguing that it suppresses the intuitive qualities that are inherent in hand-drawn sketches. His skepticism towards the dominance of computer-generated designs aligns with the framework's emphasis on the irreplaceable value of open, exploratory phases in the architectural process.¹⁸

Pallasmaa critiques the modern architectural process, challenging the architect's capacity to sustain inspiration

¹⁶ Juhani Pallasmaa, *The Thinking Hand: Existential and Embodied Wisdom in Architecture*, AD Primers (Chichester, UK: Wiley, 2009), 82.

¹⁷ Pallasmaa, 99.

¹⁸ Pallasmaa, 89.

over time. “The same fusion of the external and the internal, material and mental, thought and execution takes place in the designer’s and architect’s work, although their work is usually painfully prolonged, and interrupted by less creative and intimate phases”¹⁹. **This highlights the need for our framework to nurture open drawings as tools for exploration and personal expression in the early design stages.**

Projections, another foundational category of architectural drawing, have also been deeply shaped by technological advancements. In *Words and Buildings: A Vocabulary of Modern Architecture*, Forty describes how the emphasis on drawing became so popular by the early nineteenth century, that J.N.L Durand wrote “Drawing is the natural language of Architecture.”²⁰ **This statement exemplifies the fact that by the early nineteenth century, what was once a novel approach to building buildings fueled by the latest scientific discoveries, became totally integrated into the profession of architecture.**

The development of orthographic projections, such as plans, sections, and elevations, became the standard language for communicating architectural ideas, enabling architects to convey spatial relationships and structural details clearly. As technology evolved, the nature of projection drawings was further enhanced by CAD and BIM, allowing for more precise and modifiable outputs.

Pallasmaa is particularly critical of the dominance of computerized design in early design phases, arguing for the **irreplaceable value of hand drawing.** “The computer undoubtedly expedites most aspects of architectural production decisively... However, the problems of fully computerized design are evident particularly in the most sensitive and vulnerable early phases of the design process when the architectural essence of the building is conceived and determined”.²¹ **His suspicion towards the “false precision” of computer images compared to the “natural vagueness” of hand drawings resonates strongly with the rationale for prioritizing manual techniques in the open phases of our framework.**

Robin Evans, in his theory of drawing as translation, highlights this dual nature of projections. Drawing, for Evans, is a form

¹⁹ Pallasmaa, 84.

²⁰ Forty, 30.

²¹ Pallasmaa, 95–96.

of language that translates the architect’s vision into a set of instructions for building.²² **However, in this process of translation, something is inevitably altered or lost. Evans argues that architects must suspend disbelief, accepting that their drawings will always represent a disembodied version of the final structure.**²³ **This detachment between drawing and building is a core characteristic of closed drawings, where precision and technical clarity are prioritized over ambiguity and discovery.**

The instrumentality of drawing, therefore, is not just about the tools used but also about the ways in which those tools influence the architect’s engagement with the design process. **As Evans notes, architectural drawing has a unique power to shape the very ideas it represents, yet this power is mediated by the technologies that enable it.**²⁴ **The precision of CAD, for example, allows for more detailed and accurate projections, but it also distances the architect from the material immediacy that hand drawing affords.**

As we continue to explore the role of drawing in architecture, it becomes clear that technology is not merely an aid to the design process but a defining layer of how architects think, communicate, and create. The historical shift from hand drawing to digital tools illustrates how the instrumentality of drawing evolves with technological advances, shaping the way architects navigate the balance between exploration and precision, ambiguity and closure.

In this context, instrumentality serves as a necessary analytical layer for understanding the different types of architectural drawings, from open, exploratory sketches to closed, precise projections. It allows us to see how drawing is not simply a neutral medium but an active participant in the design process, shaped by and shaping the technologies with which it interacts. Understanding this dynamic is essential for engaging with the future of architectural drawing, especially as AI and other advanced technologies continue to influence the field.

²² Evans, *Translations from Drawing to Building*, 154.

²³ Evans, 154.

²⁴ Evans, 154.

The Open-Closed Drawing Continuum

A key assertion of this thesis is that architectural drawing exists on a continuum, a concept that reflects the dynamic and iterative nature of the design process. This continuum acknowledges that architectural drawings are not static, but instead evolve as part of a fluid interplay between exploration and precision. The value of this framework lies in its ability to account for the varying degrees of ambiguity and specificity that drawings can embody at different stages of the design process. By recognizing the fluidity between these states, the framework provides a structured way to understand how architectural drawings shift focus as a project progresses from initial ideas to detailed execution.

This continuum serves as a critical tool for navigating the inherent complexities of architectural design. It allows architects to recognize that their drawings may transition through phases, sometimes leaning toward greater exploration, at other times focusing on the need for clarity and precision. This adaptability is essential to a successful design process, as it enables the architect to move between intuitive ideation and technical resolution. The ability to oscillate between these modes – without feeling restricted by a linear progression – fosters innovation while ensuring that practical considerations are addressed.

Later, the specific characteristics of Open and Closed drawings will be explored in detail to illustrate how this continuum functions in practice. These distinctions provide insight into how architectural drawings can facilitate both the imaginative and the technical aspects of design, reinforcing the framework's importance in guiding architects through the design journey. By setting up these key characteristics, this framework ensures that architects can maintain creative freedom while also addressing the necessary rigor of design execution.

Open Drawing

Open drawings represent the foundational end of the Open-Closed Drawing Continuum, embodying the spirit of exploration, imagination, and intuitive expression. These drawings are characterized by their fluidity, ambiguity, and emphasis on fostering a deep connection between the designer's subjective experiences, cognitive processes, and the emerging architectural concept.

In this state of openness, drawings serve as direct conduits for the free-flowing articulation of ideas, transcending the constraints of predetermined rules, conventions, or technical specifications. They prioritize the capture of conceptual essence over adherence to prescriptive guidelines, allowing the architect to engage in a process of discovery and creative risk-taking.

The physical act of drawing plays a crucial role in the open drawing process, as emphasized by Juhani Pallasmaa's concept of "embodied creation." The tactile interaction with drawing tools and materials facilitates a direct and visceral connection between the designer's cognitive processes and the act of mark-making. This embodied engagement supports the formation of intuitive connections, enabling architects to tap into their subconscious understanding of space, form, and experience.

Open drawings embrace ambiguity and the undefined nature of early ideation stages, inviting architects to explore unconventional solutions and challenge conventional assumptions. They encourage a holistic approach to design exploration, considering the multifaceted aspects of architecture, including social, cultural, environmental, and experiential dimensions.

Furthermore, open drawings foster a deep connection with the architect's imagination and subjective experiences, serving as vehicle for personal expression and the manifestation of unique design visions. They allow for the integration of diverse influences, perspectives, and conceptual frameworks, facilitating the synthesis of disparate ideas into cohesive architectural narratives.

Closed Drawing

Closed drawings mark the final stage of the design process, where the architect's vision is translated into precise, technically detailed representations. These drawings adhere strictly to industry standards, regulatory requirements, and practical construction considerations. They are essential for ensuring the design can be accurately executed in the real world.

Unlike open drawings, which focus on exploration and ambiguity, closed drawings provide definitive, clear instructions for bringing the design to life. They include all necessary technical information, such as precise dimensions, material specifications, structural details, and compliance with building codes and regulations. At this stage, the emphasis shifts from creative exploration to ensuring effective communication and an accurate translation of the architect's intent into the built environment.

Precision and standardization are key in closed drawings. They serve as the primary tools for conveying the final design to builders, stakeholders, and regulatory bodies. Accuracy is paramount, with technical specifications, measurements, and adherence to best practices guiding the process.

Rendering techniques, such as photorealistic visualizations and detailed construction drawings, are often used to provide a clear and impactful representation of the design. These tools help clients and stakeholders envision the finished project and reduce the risk of misinterpretation during construction.

In summary, closed drawings bridge the gap between the architect's creative vision and the practical demands of construction. They transform initial, exploratory concepts into rule-based, construction-ready documents, ensuring the design can be realized effectively through collaboration among various disciplines.

Inputs and Outputs

In the Open-Closed Drawing Framework, the roles of inputs and outputs are key to understanding how architectural drawings move from rough ideas to detailed, precise plans. This framework helps explain how drawings change throughout the design process, showing how different inputs and outputs shape a project as it develops.

Inputs are the starting points that guide the design process. They include both tangible elements, like hand-drawn sketches or site data, and intangible elements, such as design inspiration or user requirements. Early in the process, these inputs allow for flexibility and creative exploration. For example, hand-drawn sketches capture broad ideas without being tied to specific details. Mood boards, with their collection of images, materials, and colors, help set the tone and direction for the design. Site analysis provides context, including environmental and cultural factors, while user requirements offer a flexible framework based on the needs of clients or stakeholders.

As the design progresses, inputs become more refined but still maintain some flexibility. These semi-open inputs include refined sketches, 3D models, and diagrams, which clarify design ideas while leaving room for further development. Feedback from clients and peers also becomes more important during this phase, helping adjust and improve the design without finalizing every detail.

In the final stages, closed inputs provide precise, detailed information. These include construction drawings, specifications, and digital models, which are necessary for building. Construction drawings include specific dimensions and materials, while digital models ensure that all elements of the design fit together accurately. Regulatory inputs, such as building codes, also come into play, setting fixed boundaries that the design must follow.

Outputs are the results of processing these inputs at each stage of the design. Early outputs, like conceptual diagrams or broad shapes, allow for flexibility and further exploration. As the design takes shape, semi-closed outputs emerge, such as refined sketches and models, which provide a clearer direction while still allowing for changes. By the end of the process, closed outputs, like final construction documents and detailed

models, give the precise information needed for the project to be built.

The process of moving from inputs to outputs is iterative. Inputs guide the development of outputs, and outputs provide feedback that helps refine the inputs. AI tools can assist in this process, especially in the middle stages, where balancing flexibility and precision is important. However, human judgment is critical, particularly in the early stages when the design is still taking shape and in making final decisions.

This framework provides a clear, structured way to think about architectural design. It allows architects to work through the complex process of turning an idea into a building, using both creativity and technology to move from early ambiguity to precise execution.

Inputs and Outputs in the Context of Generative AI

In the context of architectural drawing, the relationship between inputs and outputs becomes increasingly important with the introduction of generative AI. Traditionally, inputs such as hand-drawn sketches, site analysis, and user requirements form the basis of the design process, guiding exploration and decision-making. Outputs, like refined sketches, models, and technical drawings, represent the tangible outcomes of this process. The introduction of generative AI enhances this dynamic by increasing the speed and scope with which inputs can be processed and transformed into outputs, creating new opportunities for efficiency and creativity.

With AI, the importance of inputs grows even more. Simple sketches, diagrams, or even raw data can serve as starting points for the AI to generate multiple design variations. The quality and nature of these inputs significantly influence the AI's ability to produce meaningful and innovative outputs. In the early, open stages of design, where ambiguity is an asset, AI allows for broad and rapid exploration, producing a variety of options for the architect to consider. This transforms the traditional input-output cycle into a more iterative and dynamic process, where outputs can be quickly assessed, refined, and reintroduced as new inputs. This continuous cycle speeds up the exploration process, allowing the architect to test ideas faster and with more flexibility than manual methods alone would allow.

The AI-generated outputs act as valuable feedback within the design process. These outputs – whether they are design variations, new forms, or suggested refinements – are not final solutions but rather intermediate steps that inform further design decisions. The architect evaluates these AI-generated outputs, decides which elements to refine or reject, and feeds the selected elements back into the design process. This establishes a responsive and iterative design cycle where the architect remains in control, ensuring that the design aligns with their creative vision while benefiting from the AI's capacity to generate new ideas quickly.

A pattern emerges when considering the range of architectural drawing methodologies. Drawings that fall on the open end of the Open-Closed Drawing Continuum – such as exploratory

sketches and conceptual diagrams – benefit most from the generative capabilities of AI. These open-ended drawings, characterized by their ambiguity and flexibility, align well with AI's strengths, including the ability to generate multiple design options and introduce new perspectives. AI thrives in the early, open stages of design, where broad creative exploration is essential, amplifying the architect's ability to push boundaries without the constraints of manual iteration.

In contrast, drawings closer to the closed end of the continuum – such as detailed renderings, construction documents, and technical projections – are less impacted by AI's generative abilities. These drawings prioritize precision and technical clarity, leaving less room for the creative exploration AI excels at. In these cases, AI's role shifts from generating new ideas to refining and optimizing the technical aspects of the design, ensuring accuracy and improving efficiency. However, its contribution in these stages is more limited to enhancing existing outputs rather than introducing novel ideas.

This thesis focuses primarily on the open end of the drawing spectrum, where AI's generative potential is most valuable. The more open a drawing, such as early sketches or conceptual diagrams, the more AI can contribute by expanding the range of possibilities. In these early stages, where ambiguity is an advantage, AI works alongside the architect, helping to iterate quickly and offering new directions for consideration. These stages present the greatest opportunities for AI to enhance creativity by allowing the architect to test and refine ideas with immediate feedback.

Ultimately, AI enhances the architectural drawing process by accelerating the iteration cycle and expanding the scope of exploration, particularly in the open stages of design. As the process moves toward more closed, technical stages, AI's role transitions to one of optimization and refinement, where its impact on creativity is more constrained. The Open-Closed Drawing Continuum illustrates this balance, showing that AI's most significant value lies in the early conceptual phases, enabling rapid exploration and creative discovery. However, the architect's role remains critical throughout the process, as they guide and manage the AI-driven iterations to ensure the final design retains its core creative intent.

In conclusion, while AI plays a role in refining technical drawings at the closed end of the continuum, its most profound impact is in the open, conceptual stages. Here, it acts as a tool for iteration and exploration, enabling architects to engage more fully with their creative process. The Open-Closed Drawing Framework highlights how AI can amplify the potential for open, exploratory design, while human judgment and creativity remain central in shaping the overall vision.

Part II Drawing in the Age of AI

RQ2: How does generative AI
disrupt traditional architectural
drawing Processes?

A Note on Rapidly Evolving Technology

In the early stages of this thesis, the interest in Artificial Intelligence (AI) was closely tied to a broader exploration of the evolution of Design Drawing in the digital age. Over the past two years, the landscape of AI research and its applications has shifted dramatically. The rapid pace at which AI technology advances presents both challenges and opportunities for architectural research and practice.

One of the primary challenges is that AI technology evolves so rapidly that any focus on specific tools risks becoming outdated. This is a concern for research that examines contemporary AI technologies, which could quickly become obsolete by the time the work is published. To address this issue, this thesis emphasizes exploring broader innovations in AI with long-term potential for influencing creative processes, rather than becoming too focused on specific, short-lived tools.

The central focus of this research is understanding how AI can enhance the creative process in architecture, a field traditionally guided by human intuition and experience. By examining overarching trends and breakthrough innovations in AI, the research seeks to uncover how these technologies can complement and augment architectural creativity. This approach offers a flexible framework for understanding AI's role in design, allowing the research to adapt as the technology continues to evolve.

This section provides a broad overview of AI's rapid evolution, emphasizing the importance of focusing on fundamental innovations rather than temporary specifics. This broader perspective ensures that the research remains relevant over time, even as the technologies change. It aligns with the overarching aim of the thesis: to explore how AI can transform both the practice and pedagogy of architecture by enhancing the design process while maintaining the central role of human creativity.

Image-Based Generative Artificial Intelligence

In this thesis, architectural drawings are positioned on a continuum from ambiguous to specific – or more precisely, from open to closed. This framework is essential for understanding the role that image-based generative artificial intelligence (AI) might play in architectural design and how it may evolve to reshape the design landscape. However, it is also important to have a basic understanding of the current tools available for engaging with image-based generative AI.

The available tools can be divided into three main categories: Text-to-Image, Hybrid, and Image-to-Image. These categories differ in their functionalities and how they generate and refine images based on user inputs.

Text-to-Image tools generate images solely from textual descriptions, translating words into visuals. These tools are particularly valuable for creating new visuals from conceptual ideas without the need for starting visual material. Hybrid tools combine text-to-image and image-to-image capabilities, allowing users to create images from text and modify or enhance existing images. This dual functionality makes hybrid tools versatile, supporting more complex workflows that require both creation and modification. Image-to-Image tools, in contrast, focus entirely on transforming or enhancing pre-existing images. These tools are useful when the goal is to refine an image – whether by applying styles, colorizing, or altering its visual properties – rather than generating new images from scratch.

Each of these categories serves a distinct purpose: text-to-image emphasizes conceptual creation, hybrid tools offer flexibility, and image-to-image specializes in refining existing visuals. The next section will explore specific tools in each category, providing context for the eleven exercises in augmented design that follow in this thesis.

Language as a Medium for Generating Images

In the context of this thesis, language plays a pivotal role in architectural drawing, particularly when working with generative AI. Traditionally, architectural drawings have been driven by visual cues – sketches, lines, and projections that translate abstract ideas into tangible designs. However, as generative AI becomes a tool within the architectural process, language itself has transformed into a medium through which new images and ideas are generated. This thesis's exercises demonstrate how language – both in its descriptive and evocative forms – becomes a powerful prompt, capable of stimulating creativity from both humans and machines alike.

Central to this shift is the framework of Contrastive Language-Image Pre-training (CLIP), a model developed by OpenAI, which underpins many text-to-image generation tools, including DALL·E. CLIP leverages large-scale datasets of images and text to understand how specific words, phrases, and descriptions correlate with visual representations. In this context, AI doesn't "see" in a traditional sense but statistically interprets language inputs to generate visual outputs. For architects, this opens up new possibilities: rather than relying solely on hand-drawn sketches, designers can engage with AI by crafting textual prompts that lead to the generation of novel architectural forms.

This interaction with AI invites a critical question: without images, is the entire thesis essentially a text prompt for architectural thinking through drawing? In many ways, the absence of images in this thesis serves as an extension of the same principle at work in AI-based image generation. Just as architects feed text prompts into AI models to generate visuals, this text itself serves as a prompt, encouraging readers to visualize, imagine, and engage with the concepts explored within the exercises.

The exercises in Part III of this thesis challenge participants to engage with both the human act of drawing and the machine's generative capabilities. For example, exercises like "Food Colors" and "Hybrids" are designed to encourage participants to create sensory-rich descriptions and input them into AI systems. The AI's interpretations, in turn, provoke further exploration and refinement in the human-led drawing process. This back-and-forth between human language and machine

interpretation emphasizes how text has become a tool for both visual creation and architectural thought.

Ultimately, language in this thesis operates on two levels: it serves as a conceptual framework for discussing architectural theory and as a practical tool for generating images through AI. By embracing this duality, the thesis reinforces the notion that architectural drawing in the AI age is no longer confined to visual marks on paper – it extends into the realm of linguistic prompts, which can be as generative and creative as traditional sketching methods.

Critical Perspectives on AI and Ethics in Architecture

While this thesis explores the generative potential of AI in architectural drawing, it is essential to address the growing concerns regarding the ethical implications and evolving societal positions on the use of AI. As AI becomes increasingly embedded in design practice, critical questions arise about its broader impacts – especially its role in shaping creative processes, ethical boundaries, and social responsibility.

Kyle Steinfeld's socio-technical history of text-to-image generative models provides crucial context for understanding the implications of using AI in architectural practice. Steinfeld outlines how text-to-image tools like MidJourney, DALL·E, and Stable Diffusion emerged not from singular, monolithic developments but through a series of informal innovations created by communities of unaffiliated technologists. These innovations, which developed outside of traditional institutional frameworks, reflect the open, accessible nature of current AI tools. However, they also raise important questions about data provenance, accessibility, and bias. AI systems are trained on vast datasets, often scraped from the internet without clear attribution or consent, making the technology vulnerable to perpetuating biases or reflecting the skewed representations present in the data it consumes. This context challenges the idea of AI as a neutral tool and foregrounds its role as a cultural and social actor, influencing the design outputs it generates.²⁵

The concern with these models is not merely their technical functionality but their ability to shape architectural aesthetics and practice through these “baked-in” biases. For instance, AI tools, despite their generative capacity, can inadvertently reinforce existing architectural tropes, privileging certain styles, materials, or design approaches that align with dominant narratives. This issue calls into question the neutrality of AI and highlights the importance of critical engagement with the tools architects are using. AI is not a neutral agent – it is trained within specific social and cultural contexts, which means it carries the biases inherent in the data it processes and the values of its creators.²⁶

²⁵ Kyle Steinfeld, “Clever Little Tricks: A Socio-Technical History of Text-to-Image Generative Models,” *International Journal of Architectural Computing* 21, no. 2 (2023): 212–13, <https://doi.org/10.1177/14780771231168230>.

²⁶ Steinfeld, 214.

Additionally, James Bridle raises ethical concerns about the opacity and potential consequences of AI's growing autonomy. Bridle emphasizes that AI systems often operate as “black boxes,” making decisions and generating outputs in ways that are difficult for even experts to fully understand. This lack of transparency becomes problematic in fields like architecture, where the creative and social responsibility of a designer is paramount. The risks associated with delegating creative agency to AI – such as the loss of authorship, originality, and accountability – are critical issues that architects must confront as they integrate AI into their workflows.²⁷

Bridle also warns against the potential for AI to perpetuate inequality by favoring those with access to the most advanced tools and technologies. In architectural practice, this could lead to a homogenization of design, where projects are driven by the same algorithms and datasets, diminishing the diversity and richness of architectural expression.²⁸ Such a trend would contradict the ethical obligations of architects to respond sensitively to context, culture, and community needs.

In light of these ethical concerns, it is necessary to frame the use of AI within architectural drawing as part of an ongoing, critical dialogue rather than a purely technical tool for efficiency or exploration. Architects must maintain an active role in questioning the values, biases, and implications of the tools they adopt. As this thesis demonstrates through its exercises, AI can augment creativity, but it also demands conscious oversight. Architects must critically assess the ways in which AI-generated imagery influences their design decisions, ensuring that the tool serves the creative process rather than directing it.

²⁷ Steinfeld, 217.

²⁸ Steinfeld, 219.

Text-to-Image Tools

With the ethical dimensions of AI in mind, it is worth offering a summary of some of the tools available. Text-to-image tools are designed to generate images directly from textual descriptions, without the capability to modify existing images. These tools have become foundational in AI's creative applications, enabling users to translate textual ideas into visual forms.

MidJourney is a leading tool in this category, known for its ability to produce artistic and surreal visuals from text prompts. Launched in 2022 by David Holz, it has gained popularity among digital artists for its unique, dreamlike outputs.

Another prominent tool is DALL-E 3, developed by OpenAI. It is renowned for generating highly detailed and imaginative images from text, offering enhanced creative possibilities and precision in visualizing prompts.

Imagen 2 (in Gemini, formerly Google Bard) represents Google's advanced entry into the text-to-image field, excelling in producing photorealistic images from text. It reflects Google's deep investment in AI research.

Craiyon, formerly known as DALL-E Mini, provides a more accessible approach to text-to-image generation. While it offers simpler outputs compared to advanced tools, it remains popular for its ease of use.

Wombo Dream specializes in creating vibrant, abstract images from text. Developed by the Wombo AI team, it is particularly favored by users interested in imaginative and unconventional aesthetics.

Adobe Firefly, integrated into Adobe Creative Cloud, launched in 2023. It generates high-quality, commercially viable images from text prompts, making it a go-to tool for professionals working within Adobe's ecosystem.

Generative AI by Getty Images produces licensable content from text prompts, catering to professionals in media and advertising. It focuses on creating commercially viable, high-quality visuals suitable for a wide range of industries.

Hybrid Tools (Text-to-Image and Image-to-Image)

Hybrid tools provide the flexibility to both generate images from text and modify existing images, offering users the best of both worlds. These tools are particularly valued for their versatility in creative processes.

Stable Diffusion is a key example of a hybrid tool, offering capabilities for both text-to-image generation and image-to-image modification. Developed by Stability AI and released in 2022, Stable Diffusion has become a favored tool among developers, researchers, and artists who require both creative freedom and technical flexibility.

Stability AI DreamStudio serves as a user-friendly interface for Stable Diffusion, making it accessible to a broader audience. DreamStudio allows users to engage in both the creation and modification of images, using text inputs or existing images as starting points, thereby expanding the range of creative possibilities.

Runway ML is another prominent hybrid tool, widely used by digital artists, filmmakers, and designers. Launched in 2018, Runway ML provides extensive tools for both image manipulation and video editing, making it a go-to platform for multimedia art. Its combination of text-to-image and image-to-image capabilities has established it as a versatile resource in creative industries.

Viscom operates similarly, though it is less widely known. This tool allows for both generating images from text and modifying existing images, finding its niche among users who value its specific functionalities and versatility.

Artbreeder is also a notable hybrid tool, enabling users to "breed" new images by mixing attributes from different sources. It supports both text-based input and image manipulation, making it popular among character designers, concept artists, and others exploring evolutionary image creation.

Image-to-Image Tools

Image-to-image generative AI tools are specifically designed to transform, enhance, or manipulate existing images, often by applying artistic styles or effects. These tools are crucial in workflows where the primary goal is to modify or improve upon a pre-existing visual rather than create one from scratch.

DeepArt.io is one of the most well-known tools in this category, offering users the ability to convert photos into images that mimic the styles of famous artists. Launched in 2016, DeepArt.io uses convolutional neural networks to apply artistic styles to images, making it a popular choice for those looking to create art-inspired transformations.

Adobe Photoshop (Neural Filters) is a significant advancement in image-to-image AI technology. Integrated into Adobe's industry-standard Photoshop software, Neural Filters allow for sophisticated image modifications, such as altering facial expressions, colorizing black-and-white photos, and applying various artistic effects. This tool is widely used by professionals for tasks ranging from photo editing to creative art projects.

Runway ML, in addition to its hybrid capabilities, also plays a significant role in the image-to-image space. It offers robust tools for video editing and image manipulation, making it invaluable for artists and creatives working across multiple media. The platform's focus on accessibility and community support has made it a popular choice for both professionals and amateurs.

Prisma, recognized for its mobile-friendly application, transforms photos into stylized artworks using a variety of filters. Since its launch in 2016, Prisma has brought artistic style transfer to a broad audience, offering a quick and accessible way to apply artistic effects to everyday images, particularly for social media content creation.

Deep Dream Generator is famous for its ability to create surreal, abstract visuals from existing images. Developed by Google in 2015 as an experiment in convolutional neural networks, Deep Dream Generator became well-known for its distinctive, psychedelic effects, making it a favored tool for artists exploring visual abstraction and creativity.

In the context of architectural drawing, understanding the three categories of image-based generative AI tools – text-to-image, hybrid, and image-to-image – is essential for grasping their contemporary applications in the field. These categories help clarify how generative AI is being integrated into architectural workflows, particularly in two main areas: Conceptual Design and Rendering or Visualization.

Conceptual Design or Brainstorming represents the first key application of these tools in architecture. Here, AI is leveraged to generate preliminary ideas, create mood boards, modify reference images, and produce initial visuals that serve as inspiration or references for further design work. Drawings produced in this phase typically align with the more “Open” end of the Open-Closed Drawing Continuum, functioning as exploratory catalysts rather than finalized design solutions.

This conceptual approach to the application of generative AI relies on a cyclical and iterative process (see fig. 1) of finetuning inputs – whether the inputs consist of images, text prompts, or a combination of both – in order to generate outputs that align with the goals of the early conceptual stages of a project.

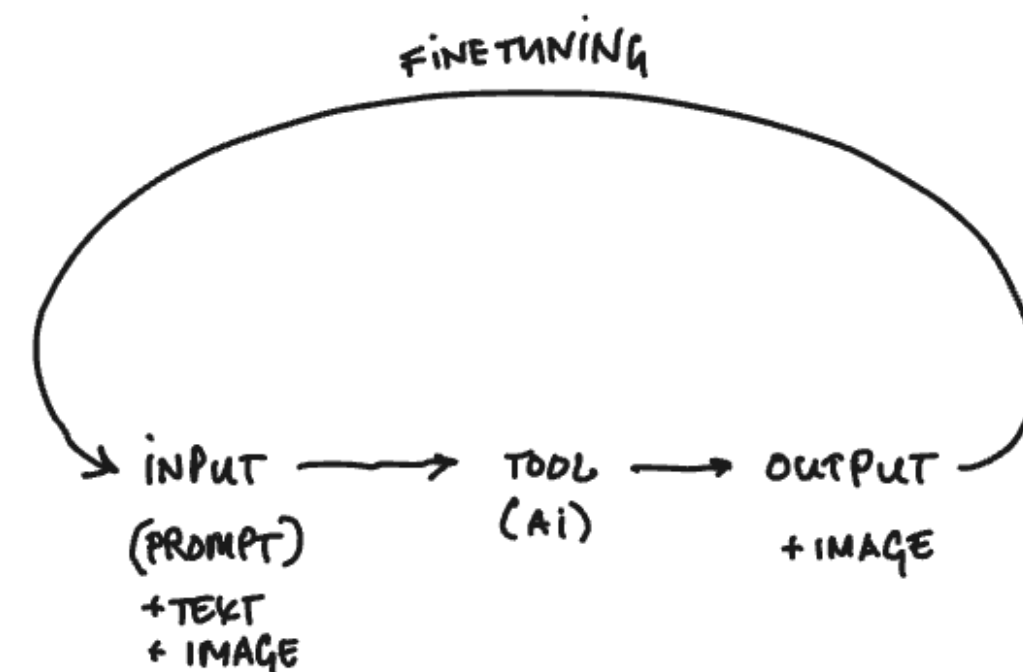


Figure 1. Conceptual Generative AI workflow. By Author.

In this instance, the AI functions in the same way that a mood board, design precedents, or even very early sketch models do. That is to say that these architectural drawings are produced almost exclusively to fuel future explorations and to refine the design direction. The outputs of this conceptual generative AI workflow will rarely, if ever, make it into the later stages of the design process without being absorbed into more closed drawings.

The second application area, Rendering or Visualization, focuses on creating more “finished” images that describe the design in greater detail, often with specific aspects of the design already resolved. This category encompasses everything from final presentation renders to orthographic projections. The outputs here are generally more varied in their level of Openness or Closedness but tend to gravitate closer to the “Closed” end of the continuum than those in the conceptual design phase. These tools facilitate the creation of drawings that convey a more refined and resolved vision of the architectural design, serving as key components in communicating the final design intent.

Unlike in the conceptual application of generative AI which can neatly tack on to the front end of an established workflow in Architectural Drawing and Design, the applications of generative AI to rendering and visualization in architectural drawing are more complex in the way that they augment and disrupt established workflows. For this reason, it is important to return to a more traditional Architectural Drawing and Design Workflow as a means of evaluating these augmentations and disruptions.

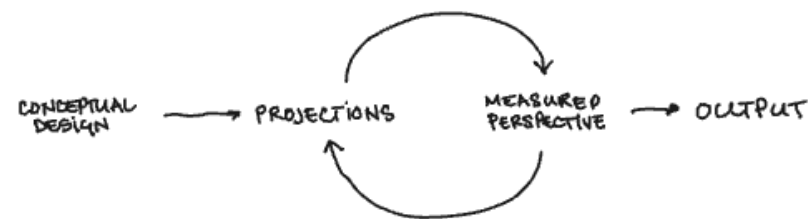


Figure 2. Traditional Rendering Workflow. By Author.

The traditional Architectural Drawing workflow for visualization (see fig. 2) can be simplified as moving from an initial conceptual design and research stage to a more refined measured perspective rendering based on the projections or orthographic drawings.

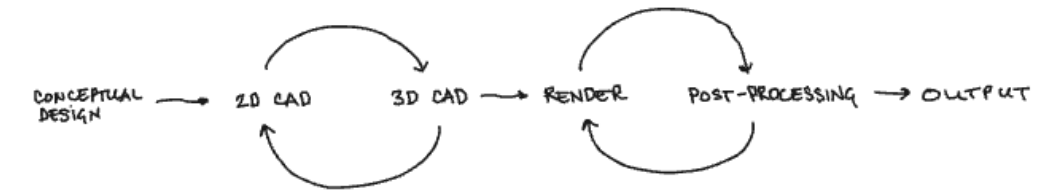


Figure 3. Digital Rendering Workflow. By Author.

With the introduction of Computer Aided Design (CAD) in architecture, the traditional rendering process largely remained the same (see fig. 3), with the traditional tools being replaced with digital ones. Of course, the key difference between digital and traditional workflows is the fact that digital tools are far more conducive to iteration and reproduction than traditional tools and save time in the production of drawings.

The diagram above (see fig. 3) is an extremely simplified version of a digital rendering workflow. There is room for multiple variations and different tools, but the general idea of moving from Open to Closed remains the same. For example, below, (see fig. 4) is a diagram of a more personalized rendering and visualization workflow where the goal is the production of an image, so the tools used in achieving that goal are totally unimportant if they are able to move the image from ambiguity to specificity – Open to Closed – throughout the design process. In this example, that likely means that the desired vignette is sketched in a notebook, then a partial model is constructed in Rhino3D, that model is then rendered with something like V-Ray for Rhino, and then the final image is post-processed in Photoshop. What is important here, is not the tools themselves, but understanding that different tools are deployed to move the design from Openness to Closedness as more of the design becomes described.

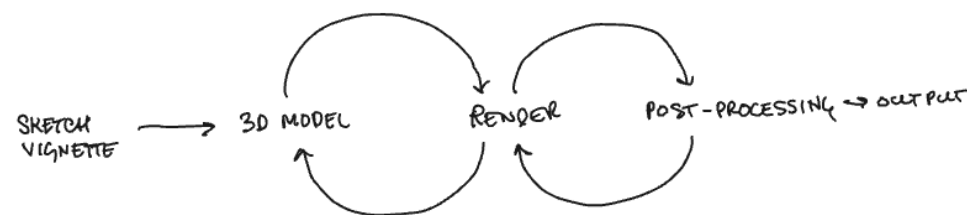


Figure 4. Condensed Digital Rendering Workflow. By Author.

When we begin to consider the addition of generative AI to these processes, we must consider the AI tools at our disposal as instruments in achieving our design goals. In that light, there is no one singular process for what we will later describe in detail as Augmented Design Drawing. Through a combination of the Open-Closed Drawing Continuum framework, and the translation for Frascari's *Eleven Exercises in the Art of Architectural Drawing* into a contemporary technological context – the Age of AI – this thesis makes an argument for the value of structured engagement with the instrumentality of generative AI without proscribing a specific path forward.

Grokking and Semilattices

The field of large language models (LLMs) is rapidly evolving, with researchers and developers constantly pushing the boundaries of what these models can achieve. One of the most intriguing phenomena in the development of LLMs is the concept of “grokking.” Grokking refers to a sudden leap in a model's performance during training where it transitions from simply memorizing patterns to deeply understanding the underlying structure and relationships within the data. This phenomenon has significant implications for the future of LLMs, as it suggests that these models can develop a more human-like understanding of language and reasoning. By achieving grokking, LLMs can potentially generalize better to new tasks and domains, requiring less training data and fine-tuning. Researchers are actively exploring ways to reliably induce and harness grokking in LLMs, which could lead to more efficient and capable models in the near future.²⁹

Another promising direction in LLM development is the incorporation of more complex and interconnected representations such as semilattices. Drawing from Christopher Alexander's work on design patterns and living structures, language can be conceptualized as a complex system of overlapping and interrelated elements rather than a strict hierarchy.³⁰ By incorporating semilattice-like structures into LLMs, it is possible to capture the nuanced and context-dependent nature of language more effectively. This could involve developing new architectures or training methods that allow LLMs to learn and represent the multi-dimensional relationships between words, phrases, and concepts. While semilattices have not been explicitly used in current LLM architectures, researchers are exploring ways to move beyond simple hierarchical representations and capture the rich interconnectedness of language. For example, some models are incorporating graph-based structures or attention mechanisms that can attend to multiple parts of the input simultaneously, resembling the overlapping sets found in semilattices.

²⁹ “8 Challenges Of Building Own Large Language Model (LLMs),” Labellerr, August 11, 2023, <https://www.labellerr.com/blog/challenges-in-development-of-llms/>.

³⁰ Rajvardhan Patil and Venkat Gudivada, “A Review of Current Trends, Techniques, and Challenges in Large Language Models (LLMs),” *Applied Sciences* 14, no. 5 (January 2024): 2074, <https://doi.org/10.3390/app14052074>.

Integrating insights from grokking and semilattices into LLM development could lead to more powerful and adaptive models that can better handle the complexities of human language. By fostering a deeper understanding of the underlying structures and relationships within language, these approaches can potentially unlock new levels of performance and generalization in LLMs. However, realizing this potential requires addressing significant challenges, such as the computational complexity of training and deploying models with more intricate representations, as well as ensuring the interpretability and controllability of these advanced LLMs. Nonetheless, the emergence of grokking and the inspiration drawn from semilattices provide promising avenues for advancing the field of language modeling and bringing us closer to truly intelligent and understanding artificial systems.

The Rise of Multi-Agent Ai Systems

One of the most significant recent developments in AI is the shift from single-agent systems to multi-agent collaboration. While traditional AI approaches have focused on creating individual agents with broad capabilities, researchers are now exploring the potential of multiple specialized agents working together to tackle complex problems.³¹ Multi-agent AI systems consist of several autonomous agents that interact and collaborate within a shared environment to achieve common goals. Each agent brings its own unique skills, knowledge, and perspectives to the table, allowing the system to leverage their collective intelligence to solve challenges that would be difficult or impossible for any single agent to handle alone.³² There are several key advantages to this multi-agent approach: specialization, flexibility, robustness, and emergent behavior. By assigning specific roles and tasks to different agents, each can be optimized for its particular function, leading to improved efficiency and performance compared to a jack-of-all-trades single agent. Multi-agent systems can be more easily adapted to new situations by adding, removing, or modifying individual agents as needed without having to retrain the entire system from scratch. The distributed nature of multi-agent systems makes them more resilient to failures or errors in any one component, as other agents can compensate or take over tasks as needed.³³ The interactions and collaborations among multiple agents can give rise to complex, intelligent behaviors that emerge from their collective actions, even if no single agent possesses a complete understanding of the problem or solution.³⁴

Some of the most promising applications of multi-agent AI include autonomous vehicles, robotics, scientific discovery, and financial trading. Fleets of self-driving cars that communicate and coordinate with each other to navigate complex road

³¹ Melissa Malec, "Large Language Models: Capabilities, Advancements, and Limitations [2024]," HatchWorks, March 12, 2024, <https://hatchworks.com/blog/gen-ai/large-language-models-guide/>.

³² "Future of Large Language Models," GeeksforGeeks, April 16, 2024, <https://www.geeksforgeeks.org/future-of-large-language-models/>.

³³ Angie Lee, "What Are Large Language Models Used For?," NVIDIA Blog, January 26, 2023, <https://blogs.nvidia.com/blog/what-are-large-language-models-used-for/>.

³⁴ "Get Ready for Future Innovations with Large Language Models," Express Analytics (blog), March 28, 2024, <https://www.expressanalytics.com/blog/generative-ai-large-language-models/>.

situations, optimize traffic flow, and improve safety.³⁵ Teams of collaborative robots working together in factories, warehouses, or disaster response scenarios to efficiently accomplish tasks and adapt to changing conditions.³⁶ Networks of AI agents mining vast datasets, generating hypotheses, and designing experiments to accelerate breakthroughs across various research domains.³⁷ Swarms of AI traders analyzing market data, executing coordinated investment strategies, and optimizing portfolio performance.³⁸

The rise of multi-agent AI systems represents a significant shift in how artificial intelligence is conceptualized and developed. Rather than focusing solely on creating individual agents that can handle any task, this approach recognizes the power of specialization, collaboration, and emergent behavior in solving complex problems.³⁹

Preparing for the Future of Design Thinking

The development of multi-agent AI systems also ties into the concepts of grokking, semilattices, and open drawing that have been discussed as part of the framework for understanding the evolution of AI and its potential impact on design thinking. Just as grokking represents a sudden leap in an AI model's understanding and ability to generalize, the interactions among multiple agents can lead to the emergence of higher-level intelligence and problem-solving capabilities that exceed the sum of their individual parts.⁴⁰ By sharing knowledge, critiquing each other's ideas, and building on their collective insights, multi-agent systems can potentially achieve breakthroughs that would be difficult for any single agent to reach alone.⁴¹

Similarly, the concept of semilattices, with their emphasis on overlapping and interconnected relationships, is reflected in the way multi-agent systems enable flexible, context-dependent collaboration among agents. Rather than following a rigid hierarchy, these systems allow for dynamic, adaptive interactions that can fluidly respond to the demands of the problem at hand.⁴²

Finally, the open, exploratory nature of multi-agent AI resonates with the principles of open drawing and generative design. By embracing the unpredictable and emergent properties of multi-agent collaboration, designers can potentially discover novel solutions and creative possibilities that might be overlooked by more constrained single-agent approaches.⁴³

The rise of multi-agent AI systems represents a new frontier in the development of artificial intelligence, one that aligns with the concepts of grokking, semilattices, and open drawing that have been identified as crucial for the future of AI-assisted design.

35 Aminu Abdullahi, "What Is A Large Language Model (LLM)? A Complete Guide," eWEEK (blog), February 15, 2024, <https://www.eweek.com/artificial-intelligence/large-language-model/>.
36 Rob Toews, "The Next Generation Of Large Language Models," Forbes, <https://www.forbes.com/sites/robtoews/2023/02/07/the-next-generation-of-large-language-models/>.
37 "What Are Large Language Models (LLMs)? | IBM," November 2, 2023, <https://www.ibm.com/topics/large-language-models>.
38 "The Progress of Large Language Models: Revolutionizing NLP - Lettria," <https://www.lettria.com/blogpost/the-progress-of-large-language-models-revolutionizing-nlp>.
39 "The Unspoken Challenges of Large Language Models - Deeper Insights," <https://deeperinsights.com/ai-blog/the-unspoken-challenges-of-large-language-models>.

40 Akash Takyar, "AI Agents: Capabilities, Working, Use Cases, Architecture, Benefits and Development," LeewayHertz - AI Development Company, February 16, 2024, <https://www.leewayhertz.com/ai-agents/>.
41 "The Future Is Here - How AI Agents Will Transform Work," Prompt Engineering, March 5, 2024, <https://promptengineering.org/the-rise-of-ai-agents-navigating-the-future-of-autonomous-software/>.
42 "AI and Intelligent Agents Transforming Business," Newo, <https://newo.ai/insights/the-role-of-intelligent-agents-in-global-ai-transformation/>.
43 Shiva Aryal et al., "Leveraging Multi-AI Agents for Cross-Domain Knowledge Discovery" (arXiv, April 12, 2024), <https://doi.org/10.48550/arXiv.2404.08511>.

By harnessing the power of specialization, collaboration, and emergent behavior, these systems offer the potential for transformative breakthroughs across a wide range of domains, from autonomous vehicles and robotics to scientific discovery and beyond. Designers engaging with and understanding the implications of this multi-agent paradigm will be essential for shaping the future of the field and realizing the full potential of AI as a collaborative partner in the creative process.⁴⁴

As AI continues to evolve and become more integrated into various fields, including architectural design, it is crucial for students and practitioners to understand the potential trajectory of these developments. While direct influence over the research and development of AI may be limited, the framework being proposed as part of this research provides a valuable lens for anticipating and preparing for the future of AI in the field.

As has been discussed previously, all Architectural Drawings can be organized on a continuum from Open to Closed based on the amount of specificity the drawings in question contain. Open drawing, characterized by its fluid, exploratory, and iterative nature, has traditionally been seen as a uniquely human skill. It relies on the ability to think creatively, draw connections between seemingly disparate ideas, and adapt designs based on intuition and feedback. However, as AI systems become more advanced, incorporating concepts like semilattices and grokking, a future can be envisioned where AI begins to exhibit some of these open drawing capabilities. Semilattices, as proposed by Alexander, allow for a more interconnected and context-aware representation of information, moving beyond the limitations of strict hierarchical structures. This shift towards a more flexible and adaptable way of processing information mirrors the non-linear and iterative nature of open drawing.⁴⁵

The phenomenon of grokking, where an AI system suddenly achieves a deep understanding of patterns and relationships after extensive training, suggests the potential for AI to internalize complex design principles and strategies.⁴⁶

⁴⁴ Aryal et al.

⁴⁵ “Intelligent Automation: How AI Agents Are Redefining Productivity,” The Cognitive World of Tarik Moody, March 31, 2024, <https://www.tarikmoody.com/autonomous-decision-making-how-ai-agents-are-changing-the-game/>.

⁴⁶ “Mastering AI Agents: Insights into Next-Gen Systems | Inscribe AI,” <https://www.inscribe.ai/ai-for-financial-services/ai-agent>.

As AI systems become more adept at recognizing and leveraging these interconnected patterns, they may begin to demonstrate a more intuitive and creative approach to problem-solving akin to the open drawing process.

By understanding these potential developments in AI, students of architecture and design can better prepare themselves for a future where AI becomes an increasingly powerful tool and collaborator. Rather than viewing AI as a threat to human creativity, this thesis encourages students to embrace the possibilities of human-AI collaboration. This collaboration may take various forms, such as using AI to rapidly generate and evaluate design options based on specific constraints and criteria or leveraging AI’s ability to process vast amounts of data to inform design decisions. By understanding the strengths and limitations of AI, as well as the importance of human intuition and creativity, students can learn to work alongside AI. In the final Section of this thesis, a series of exercises inspired by Frascari’s *Eleven Exercises in the Art of Architectural Drawing* will be described as a way of engaging with the instrumentality of image-based Generative AI.

[inscribe.ai/ai-for-financial-services/ai-agent](https://www.inscribe.ai/ai-for-financial-services/ai-agent).

Augmented Design Drawings

As artificial intelligence (AI) continues to evolve, incorporating concepts like grokking, semilattice-inspired representations, and multi-agent collaboration, architectural education must adapt to prepare designers for an AI-augmented future..

In architectural practice, firms should create dedicated AI research and development roles and implement structured pilot projects under strict ethical guidelines. This proactive approach will encourage responsible use of AI in design, ensuring transparency, accountability, and positive outcomes for clients and society.

To support this shift, the architectural community should develop standards and certification programs that promote transparency and fairness in AI tools. These initiatives will build trust in AI technologies and align their use with the profession's values and goals.

Navigating this AI-driven future requires a balance of humility and creativity. While AI has the potential to revolutionize design, it should be viewed as a co-creative tool that empowers designers to focus on what they do best. The aim is to use AI to enhance the design process, allowing architects to spend more time on creative problem-solving.

By integrating concepts like grokking, semilattice structures, and multi-agent collaboration with human-centered design principles, a path emerges for seamless collaboration between designers and AI, helping push the boundaries of architectural expression.

This transition will require ongoing dialogue and experimentation among architects, AI researchers, educators, and policymakers. A willingness to embrace change, take risks, and learn from successes and failures is crucial.

Ultimately, success in this AI-enhanced future hinges on developing architects who are both technically skilled and committed to ethical, social, and environmental responsibilities. By instilling these values, AI integration in architecture can benefit society and foster a sustainable and inspiring built environment.

Part III

Eleven Exercises in the Art of Augmented De- sign Drawing

RQ3: How can generative AI be
instrumentalized to empower
architects?

The Eleven Exercises in Augmented Design

In 2011, amidst the growing emphasis on digital technology in architecture, Marco Frascari,⁴⁷ an influential architectural theorist, offered a counter-narrative with his book *Eleven Exercises in the Art of Architectural Drawing: Slow Food for the Architect's Imagination*. Frascari's work challenged the prevailing notion of drawing as a mere representation tool, advocating instead for its role as a cognitive and creative act. Through his eleven exercises, Frascari sought to immerse architects in the embodied, tactile, and imaginative dimensions of drawing, urging a return to the craft's foundations principals.

Each exercise in his list is designed to explore different dimensions of drawing, encouraging architects to develop a deeper understanding of architectural representation and its relationship to the design process. The exercises often blend theory with practical drawing tasks, emphasizing the experiential and sensory aspects of creating architectural drawings.

In researching Architectural Drawing in the Age of AI, Frascari became an unexpected ally. The methodology of the 11 exercises was a fantastic starting point for this thesis work as they already address the instrumentality of architectural drawing. By translating these eleven exercises into a more contemporary context, one where image-based generative AI can be seen as a tool and is treated not so differently from a fountain pen or pencil. The challenge is not merely to integrate generative AI but to provoke, expand, and ultimately evolve the essence of drawing through the friction between human touch and machine algorithms.

⁴⁷ Notably, Marco Frascari was the director of the David Azrieli School of Architecture and Urbanism at Carleton University from 2005 to his death in 2013. "Carleton Prof Marco Frascari Found Inspiration in Architecture," ottawacitizen, accessed September 3, 2024, <https://ottawacitizen.com/news/ottawa%20&%20area/carleton-prof-marco-frascari-found-inspiration-in-architecture>.

Frascari's Influence: Drawing as Exploration and Discovery

Marco Frascari's work is particularly relevant to this thesis because of his unique perspective on drawing as a fundamental and generative act in architectural thinking, not merely as a representational tool. Frascari viewed drawing as a medium for exploration, a process that reveals and shapes architectural ideas rather than simply recording them. His exercises encourage architects to engage deeply with ambiguity, materiality, and the inherent messiness of design thinking – qualities that are increasingly relevant in the digital age, where precision and perfection are often prioritized.

In the context of generative AI, which introduces new forms of ambiguity and non-linear creative processes, Frascari's emphasis on drawing as an act of discovery resonates strongly. The core argument of this thesis – that architectural drawings exist on a continuum from open (ambiguous, generative) to closed (precise, resolved) – is deeply aligned with Frascari's rejection of drawing as a purely representational tool. His work challenges architects to embrace the unknown and the unpredictable in their design processes, much like how AI can produce unexpected and generative outcomes. Frascari's focus on the "thinking hand" parallels the way this thesis explores the interplay between human intuition and machine-generated outputs, highlighting the evolving role of the designer as both a creator and a curator in the digital design process.

Frascari's exercises are also highly relevant because they push the boundaries of what architectural drawings can do, asking architects to question not only the act of drawing but also the meanings and narratives embedded within them. This is crucial in a thesis exploring AI's impact on architectural education and practice, as AI opens up new ways of creating, combining, and interpreting images. By grounding the thesis in Frascari's exercises, I draw on a tradition that views drawing as an evolving dialogue between the hand, the mind, and the medium. This tradition offers a necessary counterpoint to the purely technical or functional approach to drawing that might be assumed when discussing digital tools. Frascari's exercises, particularly their emphasis on the tactile and symbolic aspects of drawing, provide a platform to critically explore how generative AI

both challenges and extends the boundaries of architectural representation.

In addition, Frascari's focus on the embodied, physical nature of drawing helps ground the thesis's exploration of how digital and AI tools reframe the designer's relationship to their work. By juxtaposing his analog, hands-on exercises with new AI technologies, the thesis highlights how generative AI creates opportunities to rethink traditional practices without fully discarding the embodied, intuitive dimension of drawing that Frascari championed. His work is relevant because it embodies the very tensions – between precision and ambiguity, human and machine – that are central to the arguments in this thesis.

Exercise #1: Food Colors

Theory: This exercise emphasizes the sensory and material connection between drawing and the act of eating. Frascari explores the concept of aura – how the materials used in drawing can evoke sensory experiences beyond the visual, incorporating smell, taste, and touch to create a synesthetic experience in architectural representation.

Original Instructions: Draw a sequence of building details using a pen holder completed with a good selection of different kind of nibs, and a good set of watercolor brushes on watercolor paper. Instead of dipping your nibs or your brushes in storebought inks and paints, use exclusively liquids, pastes, juices or powders that you normally eat, drink or use to spice and flavor your food.⁴⁸

Tension: The tension here arises from the interplay between the abstract interpretations of AI and the visceral, tangible experience of drawing with food. The AI provides a digital aura – an intangible, visual interpretation of flavor and texture – while the act of drawing with food substances grounds the work in the physical world. This exercise challenges the architect to reconcile the disembodied suggestions of AI with the embodied act of drawing, questioning how technology and materiality can coexist in creating architectural meaning.

Learning Outcome: Participants will learn to bridge the gap between the sensory and the visual by leveraging AI to transform non-visual experiences (like taste or smell) into architectural elements. The AI's ability to interpret abstract sensory input into visual forms pushes architects to think about how non-traditional sensory experiences can influence architectural design in ways that physical materials alone cannot. This exercise expands the boundaries of sensory perception in architectural drawing, moving beyond direct materiality to create a hybridized, multi-sensory representation.

Augmented Instructions:

1. **Generate Images:** Use a text-to-image generation tool, such as MidJourney or DALL-E, to generate images of architectural details inspired by the textures, colors, and forms of specific foods.

2. **Craft Descriptions:** Focus on describing the sensory qualities of the foods – mention attributes such as spiciness, sweetness, bitterness, or smoothness. Pay attention to how the tool interprets these descriptions into architectural forms and details.
3. **Select Images:** Review and select the AI-generated images that best evoke the food qualities you want to explore further.
4. **Transfer to Paper:** Using watercolor paper, hand-transfer the selected AI-generated architectural details, either by freehand drawing or tracing.
5. **Enhance with Food:** Once the details are transferred, enhance and alter the drawings using actual food substances (e.g., saffron, wine, coffee, or turmeric). This step adds texture, color, and an olfactory layer to your drawing.
6. **Layer the Drawing:** Build up layers of food-based pigments and textures, allowing for the natural qualities of the substances (such as staining, blotting, or dripping) to shape the final outcome.

⁴⁸ Frascari, *Eleven Exercises in the Art of Architectural Drawing*, 25.

Exercise #2: Tools

Theory: Frascari highlights the relationship between the tools used and the architectural thinking process. By crafting custom tools, architects can achieve a deeper understanding of how the medium influences the outcome, bridging the gap between manual craftsmanship and conceptual design.

Original Instruction: Construct your own drafting tools from materials like paper, wood, or plastic, tailored to the specific project at hand.

Make your own marking tools (pencils and pens that have been produced industrially are not allowed), for instance it is possible to use drinking straws or stirrers cut into quill pens.

Make your edges for drawing lines: they do not need to be straight but rather they should be related to your design intention, the same condition should be followed in the facture of the necessary squares.

Make your own compasses or dividers; disposable chopsticks provide excellent legs for a compass, you need only to fasten points or markers, and then figure out a variable joint or a tie-up one—this solution requires a divider for each different curve.

Also make a pantograph. The original use of the pantograph is for copying and scaling drawings and to enlarge the small sketches you drew at the beginning of this exercise. To make a pantograph cut four strips out of stiff cardboard or rigid plastic, about 25 millimeter wide, and 300 millimeter long. Put them together according to the picture above. Make a hole for the drawing tool. The pushpins go in upside down; you must put a piece of cork over the sharp end that sticks out, for protection. Use a nail to make a pointer. Make the fix point very heavy so it does not move.⁴⁹

Tension: The tension here lies in the gap between the imagined and the real. AI can effortlessly dream up tools that challenge the boundaries of what is physically possible, but the act of trying to manifest these tools into the physical world forces the architect to grapple with the limitations and potentials of both

digital imagination and material reality. This exercise questions how far the line between the possible and the impossible can be pushed, and what happens when the act of drawing itself becomes an experiment in material invention. The act of drawing is disrupted by tools that resist tradition, forcing the architect to adapt to new modes of mark-making that subvert comfort and precision. It's a struggle to maintain the organic touch in a field dominated by mechanical perfection.

Learning Outcome: Participants will explore how AI can push the limits of what drawing tools are and how they behave, learning to think beyond the materiality of pen and paper. By generating speculative tools that introduce unconventional or even impossible drawing behaviors (e.g., sketching with light or sound), architects will learn how to break free from conventional representations. This exercise encourages architects to rethink how the tools of drawing can evolve in a digital age, leading to unexpected forms of expression and representation.

⁴⁹ Frascari, 33–34.

Augmented Instructions:

1. **Generate Speculative Tools:** Use a generative AI tool like Stable Diffusion to create speculative images of new drawing tools that don't yet exist – imagine tools that could sketch, etch, or carve using unconventional elements like light, sound, or even thought.
2. **Select a Tool:** Review the AI-generated tools and choose one that pushes the boundaries of conventional drawing tools, reflecting your design intentions or personal curiosity.
3. **Create the Tool:** Attempt to construct the selected tool using available materials – this might involve unconventional materials (e.g., cardboard, metal, fabric) or digital fabrication methods like 3D printing.
4. **Test the Tool:** Use the constructed tool to create marks or drawings. Observe how it alters the drawing process, whether through new textures, precision, or constraints.
5. **Refine the Tool:** Based on your observations, make adjustments or refinements to your custom tool. Experiment with different methods to push its capabilities further.

Exercise #3: Improper Drawing

Theory: Frascari challenges the conventional use of digital tools by encouraging architects to explore their creative potential through “improper” use. This exercise underscores the importance of breaking free from standard procedures to discover new possibilities in architectural representation.

Original Instructions: “Take the pantograph you have built in a previous exercise and alter the ratio of connection of its arms and enlarge a drawing of a plan and a section that you are studying. The result of this improper use of the pantograph will be amazing. Then draw within this enlarged section scale figures performing mundane activities.”⁵⁰

Tension: The tension in this exercise stems from the conflict between architectural precision and AI’s unpredictable interventions. While traditional drawing seeks control, this exercise encourages embracing uncertainty and accident, exploring how these disruptions create new expressions. As the AI evolves the drawing, the architect must balance abstraction with maintaining legibility, deciding when to intervene or let go.

Learning Outcome: Participants will gain insight into how iterative distortion, driven by AI, can open up new architectural possibilities. By relinquishing control to the AI, architects will explore how digital tools challenge their traditional methods of drawing and representation, generating forms and spaces that push past human limitations. This exercise emphasizes the fluid nature of digital distortion and its potential to uncover architectural forms that are unachievable through manual methods, encouraging a new relationship between control and randomness in design.

Augmented Instructions: Instead of simply enlarging a drawing with a pantograph, use generative AI to stretch, distort, and reinterpret the structure of your drawing continuously. Follow these steps:

1. **Begin with a Base Drawing:** Start with a hand-drawn or digitally created architectural sketch, such as a plan or section.

2. **Select an AI Tool:** Use a hybrid AI tool like Stable Diffusion. These tools allow you to input your drawing and apply various transformations and distortions.
3. **First Transformation:** Upload your initial drawing into the chosen AI tool. Use textual prompts in Stable Diffusion (e.g., “distort vertically,” “warp with a wave pattern”) or the visual manipulation interface in Runway ML to apply a first layer of distortion. The aim is to introduce an unexpected transformation that breaks away from the drawing’s original proportions and geometry.
4. **Iterative Process:** Take the output from the first transformation and feed it back into the AI tool for further manipulation. Continue this iterative process multiple times, adjusting the prompts or effects with each step to push the drawing into new forms and configurations. For example, after an initial warp, you might prompt the AI to “fragment into shards” or “melt into fluid shapes.”
5. **Biological Evolution:** Treat this process as a form of biological evolution – each iteration is a mutation that builds on the previous one, allowing the drawing to evolve organically. The goal is to explore a sequence of transformations that push the drawing further from its original intent, embracing the unpredictable and the accidental.
6. **Reintegration into Architectural Language:** Once the drawing has reached a stage of rich, chaotic transformation, select the most compelling version and translate it back into a “proper” architectural language. Use CAD software (such as Rhino or AutoCAD) to reconstruct the distorted forms into a coherent architectural drawing. Embrace the irregularities introduced by the AI, integrating them as key design elements rather than smoothing them out.
7. **Final Refinement:** Use digital tools like Adobe Illustrator or Photoshop to add details, textures, and annotations, refining the drawing to balance the chaos of AI-induced transformations with the clarity of traditional architectural representation.

⁵⁰ Frascari, 64.

Exercise #4: Spolia

Theory: The exercise draws from the historical concept of spolia, the reuse of building materials in new constructions. Frascari uses this idea to encourage architects to think about how architectural elements can be recontextualized and reinterpreted in new designs, linking past and present in the act of creation.

Instruction: Create a collage using portions of plan, section, and detail drawings from various sources. Assemble these fragments into a new design, and use gold paint to highlight sectioned walls, creating a decoupage on a plywood board.⁵¹

Tension: The tension in this exercise arises from the fundamental difference between the permanence of traditional *spolia* and the fluidity of digital architecture. Whereas traditional *spolia* is about continuity, reuse, and preservation, the digital *spolia* created by AI challenges these notions by introducing elements that are ephemeral, dynamic, and speculative. The architectural fragments are not just historical objects recontextualized; they are reimagined into forms that could not exist in the real world. This tension asks the architect to grapple with what it means to preserve history in a digital age, where forms can evolve, dissolve, and behave in ways that defy the physical and material reality.

Learning Outcome: Participants will gain an understanding of how AI transforms architectural representation, particularly through the concept of spolia. They will explore how AI transcends traditional materiality, creating dynamic, evolving representations that reimagine historical fragments beyond physical limits. This exercise challenges architects to critically rethink preservation, reuse, and continuity in the digital age, embracing a speculative, interactive approach to architectural design.

⁵¹ Frascari, 73–75.

Augmented Instructions:

1. **Gather Digital Fragments:** Use AI tools to generate architectural fragments from different historical styles. Encourage the AI to explore not only traditional representations but also to push beyond: fractalized forms, fluid geometries, or impossible structures that dissolve or morph in ways analog architecture cannot.
2. **Select Digital Effects:** Choose fragments that embrace the speculative. Some might resemble traditional motifs, but push further: explore materials that shift in color, texture, or transparency in response to stimuli. These AI fragments could emulate elements like glowing stone, breathing walls, or liquid metal surfaces.
3. **Assemble with Dynamic Interactions:** In a digital design tool, assemble the fragments not as a static collage but as an evolving, interactive composition. Consider the layers and movements that digital technology allows – creating patterns that shift or glow, and surfaces that appear textured or iridescent, offering a visually engaging experience that continuously evolves.
4. **Use Digital Enhancements:** Use this opportunity to explore unique visual effects that are only possible digitally. Apply shifting hues, digital reflections, or animated patterns to simulate materials that do not exist in the physical world. Consider using patterns that change with the time, altering how the digital collage is experienced.
5. **Introduce Layers and Transparency:** Add dynamic layers to the collage that reflect how digital materials interact. For example, elements might appear to overlap, merge, or morph into one another – something traditional media cannot achieve. These digital layers should be fluid, exploring dimensionality and time in a way that would be impossible with static, physical media.
6. **Refine with Speculative Complexity:** Continuously refine the collage, allowing the evolving digital tools to generate increasingly complex patterns, textures, and forms. What is revealed in this exploration is not just historical fragments but architectural possibilities that expand our understanding of space and materiality.

Exercise #5: Scale Figures

Theory: This exercise explores the role of different bodies – human, animal, and other life forms – as mediators of scale and experience in architectural drawings. Frascari's emphasis on the human body is expanded to include diverse life forms, challenging traditional notions of architecture being exclusively human-centered. This exercise encourages a deeper examination of how various bodies interact with, shape, and experience architectural space.

Instruction: Begin a section drawing by placing scale figures in various activities like sitting, climbing, or resting. Then, add a second set of figures engaged in dance movements. These figures challenge bodily stereotypes and contribute to the building's spatial experience.⁵²

Tension: The tension in this exercise emerges from the contrast between the stability and permanence traditionally associated with architectural space and the fluid, ephemeral, and often impossible nature of the AI-generated figures and non-human bodies. The exercise challenges the architect to rethink architecture's role in accommodating not just human forms but a broader spectrum of life, thus opening up new possibilities for design and spatial experience. This exercise moves beyond a human-centered practice, inviting architects to envision spaces that respond to a variety of living beings and their interactions with the built environment.

Learning Outcome: Participants will learn to challenge conventional notions of scale and embodiment in architecture by introducing AI-generated figures that defy physical reality. The AI allows architects to experiment with new ways of representing bodies in space, revealing how the interaction between surreal figures and architecture can reshape spatial experience. This exercise encourages a rethinking of human-centric design by expanding the range of bodies that can be incorporated into architectural representation, creating new, fluid interactions between space and life forms.

⁵² Frascari, 85.

Augmented Instructions:

1. **Describe Surreal Figures:** Use a text-to-image AI tool, such as DALL-E, to generate a series of scale figures. In your prompts, describe figures engaged in abstract, surreal, or impossible activities – such as walking on air, fish swimming through walls, birds perching on invisible surfaces, or animals merging with architectural elements.
2. **Generate Diverse Bodies:** Include a range of figures in your descriptions – both human and non-human – so the AI generates diverse bodies that go beyond the typical human forms seen in architectural drawings.
3. **Select and Refine Figures:** Review the AI-generated images and select the most compelling figures. Consider how their abstract forms or movements could alter the way you think about the spatial design of your section drawing.
4. **Integrate Figures into Drawings:** Insert the chosen AI-generated figures into your architectural drawings. Use them to inform the scale and design of spaces, letting the unique behaviors and forms of these figures influence how the architecture responds to their presence.
5. **Reflect on Space:** As you integrate these figures, reflect on how the presence of surreal or non-human bodies affects the spatial experience. How do these figures challenge traditional notions of movement, stability, and interaction within architectural space?
6. **Push Boundaries of Representation:** Continue to refine the drawing, emphasizing the tension between the stability of architectural space and the fluid, impossible nature of the AI-generated bodies. Adjust the design of the space itself to accommodate these figures in unconventional ways.

Exercise #6: The Mosaic

Theory: Frascari uses the concept of the mosaic to explore the idea of fragmentation and recomposition in architectural design. This exercise encourages architects to think about how individual elements come together to form a coherent whole, reflecting the piecemeal nature of architectural development.

Instruction: Draw large sections and plans of a small building on a mosaic of paperboards arranged on a grid. This could be done using methods such as chalk drawings on a parking lot or large boards. The arrangement of the boards into a mosaic should inform the final design.⁵³

Tension: The tension in this exercise comes from the interplay between the deterministic, rule-based logic of the AI-generated patterns and the architect's own desire to impose order or meaning. The mosaic, traditionally a symbol of unity in diversity, here becomes a site of conflict between algorithmic process and human intention. This exercise questions whether architecture can emerge from purely algorithmic processes or whether it always requires the guiding hand of the human designer.

Learning Outcome: Participants will learn how AI can turn a static architectural mosaic into a dynamic, evolving composition. By embracing algorithmic patterns and speculative designs that respond to external stimuli, architects will explore how architecture can become more fluid and responsive. This exercise challenges traditional notions of architectural finality by introducing the idea that design, much like the digital medium, can evolve continuously, reflecting changing contexts and inputs.

Augmented Instructions:

1. **Generate Architectural Elements:** Use an AI tool to generate a series of architectural motifs or elements based on a specific pattern or logic. Options might include fractals, cellular automata, or algorithmic growth, where the form is determined by mathematical rules.

2. **Print or Display on Tiles:** Transfer the AI-generated motifs onto small, square tiles (physical or digital). Each tile should represent a piece of the mosaic, forming part of the larger design when arranged together.
3. **Arrange the Mosaic:** Organize the tiles into a mosaic, allowing the algorithmic patterns or growth logic to guide the arrangement. Embrace disjointed or chaotic configurations, letting the rules of the AI-generated elements dictate the composition.
4. **Manual Intervention:** Once the algorithmic mosaic is assembled, manually intervene in the design. Add or alter individual elements, introduce new shapes, or reorganize sections to introduce a layer of intentionality that contrasts with the deterministic nature of the AI-generated patterns.
5. **Reflect on Design:** As you work, reflect on how your interventions affect the overall design. Consider the balance between letting the algorithmic logic dominate the composition and imposing your own architectural intent.
6. **Refine the Composition:** Continue adjusting the mosaic, fine-tuning the relationship between the AI-generated fragments and your manual interventions. Aim to create a tension between the organic, algorithmic processes and the deliberate, human-driven alterations.

⁵³ Frascari, 107–8.

Exercise #7: Hybrids

Theory: The hybrid approach reflects Frascari's belief in the value of both traditional and digital methods in architectural drawing. By merging different techniques, architects can explore the strengths of each and how they complement one another in the design process.

Instruction: Create hybrid drawings by combining various media and techniques, reworking them through different stages to explore the interaction between digital and handmade processes.⁵⁴

Tension: The tension here lies in the ongoing negotiation between the artist's hand and the machine's algorithm. Each iteration of the drawing challenges the boundaries between the authorial control of the architect and the autonomous creativity of the AI. The hybrid drawing becomes a site of collaboration and contestation, where the final form is the result of both human and machine agency, raising questions about authorship and originality in architectural design.

Learning Outcome: Participants will develop a nuanced understanding of how to integrate digital and manual methods in a continuous loop, leveraging AI to push the boundaries of what can be achieved in hybrid drawings. By treating the drawing as an evolving document, architects will learn to embrace a dynamic interplay between human intention and AI's speculative suggestions, expanding their design process to include iterative reimagination.

Augmented Instructions:

1. **Generate a Base Image:** Start by using a text-to-image AI tool to generate a conceptual sketch. This could be a building or urban landscape, allowing the AI to create the foundational image for your drawing.
2. **Add Hand-Drawn Elements:** Once the base image is generated, print or transfer it to a medium where you can manually intervene. Layer in hand-drawn elements, such as additional architectural details, textures, or new design features, blending the digital foundation with your own craftsmanship.

3. **Integrate CAD-Generated Details:** Incorporate CAD-generated elements into the drawing. This could include precise linework or structural details, introducing a layer of technical precision that complements both the AI-generated base and the hand-drawn interventions.
4. **Apply AI-Generated Textures:** Use the AI tool again to generate new textures or materials. Apply these AI-generated textures to the drawing, adding complexity to the surfaces and materials. These textures should interact with the hand-drawn and CAD elements to blur the lines between digital and handmade.
5. **Iterate and Reinterpret:** Feed the drawing back into the AI tool to reinterpret the evolving composition. Generate new variations that blend all previous layers, allowing the AI to transform the hybrid drawing into something new. Continue this iterative process, shifting between digital and manual inputs.
6. **Refine and Finalize:** As the drawing reaches its final stages, balance the layers of AI, CAD, and hand-drawn elements. Refine the composition, making sure the digital and handmade components are in dialogue, yet preserve their distinct qualities.

⁵⁴ Frascari, 114–15.

Exercise #8: Blind Drawing

Theory: This exercise underscores the tactile dimension of architectural drawing, emphasizing the importance of non-visual senses in understanding space and form. Frascari challenges the dominance of vision in architectural representation by focusing on how drawings can be experienced through touch.

Instruction: Create a plan, section, and elevation that can be understood by a blind person, using raised lines and textures to convey architectural information.⁵⁵

Tension: The tension in this exercise emerges from the translation of digital, visual information into a tactile, physical form. It questions the dominance of the visual in architectural design and challenges the architect to create spaces that are understood and appreciated through other senses. The exercise also explores the limitations of AI in capturing the full sensory experience of architecture, asking whether a machine can truly generate a design that speaks to touch, sound, or even smell.

Learning Outcome: Participants will gain a deeper understanding of how digital tools can simulate tactile qualities through visual means, pushing the boundaries of sensory perception in architectural design. By converting AI-generated textures into tactile representations, architects will explore the potential of AI to engage multiple senses in design, expanding the traditional focus on the visual to include touch.

Augmented Instructions:

1. **Generate Tactile Visuals:** Use an AI tool to create drawings that simulate tactile experiences, focusing on textures, contours, and surfaces that could be felt rather than just seen. Descriptions should emphasize materials and shapes that could translate into physical, touchable elements.
2. **Convert to Raised-Line Drawings:** Take the AI-generated drawings and convert them into physical raised-line drawings. Use 3D printing, embossing, or other fabrication techniques to create tangible surfaces that communicate architectural information through touch.

3. **Engage with the Drawing:** Blindfold yourself or use only touch to engage with the drawing. Explore the contours, lines, and textures with your hands, attempting to understand the architectural space represented solely through tactile means.
4. **Reflect on the Experience:** Document your experience of interacting with the drawing through touch alone. Consider how well the tactile elements convey the spatial and formal qualities of the architecture. What aspects were clear or confusing?
5. **Refine the Design:** Based on your tactile experience, refine the design or drawing. Adjust textures, lines, or raised elements to enhance the clarity of the spatial representation for a blind or non-visual audience.
6. **Test the Design:** Invite others to engage with the drawing through touch, documenting their responses and feedback. Use these insights to further refine the tactile quality of the architectural representation.

⁵⁵ Frascari, 133–34.

Exercise #9: The Single Drawing

Theory: Frascari advocates for the use of detailed, layered drawings as a means to convey complex architectural ideas within a single image. This exercise highlights the importance of depth and precision in drawing, where each layer and scale informs the overall design.

Instruction: Develop a single drawing that encapsulates multiple scales and projections, focusing on details rather than a whole. Use guiding principles for construction, allowing the drawing to serve as a comprehensive representation of the design.

For this exercise, the drawing is restricted to a single sheet of paper for the entire development. All work is to be developed on one surface including sketching, study of precedents, technical detailing, and all this is done, using at the same time, multiple drawing scales.⁵⁶

Tension: The tension arises from the continuous back-and-forth between human precision and AI interpretation. The single drawing becomes a living document, constantly evolving as it absorbs both human and machine input. This exercise challenges the traditional notion of the drawing as a static representation, proposing instead that it can be a dynamic, collaborative process that reflects both the architect's intentions and the AI's suggestions.

Learning Outcome: Participants will learn to explore the dynamic interplay between physical materiality and digital manipulation, creating hybrid drawings that push beyond the limitations of paper. By layering AI-generated abstractions over traditional drawings, architects will understand how duality can be expanded through technology, creating new, multi-dimensional architectural representations.

Augmented Instructions:

1. **Generate a Conceptual Sketch:** Use an AI tool to generate a broad conceptual sketch that includes multiple layers of information, such as topography, building forms, infrastructure, and vegetation. This initial sketch serves as the foundation for the detailed work to follow.

2. **Refine by Hand:** Begin manually refining the AI-generated sketch, adding layers of hand-drawn details. Focus on integrating technical precision, architectural elements, and personal annotations that enhance the richness of the drawing. Use multiple scales to show different levels of detail within the same drawing.
3. **Iterative Detailing:** Continuously develop the drawing by layering in additional details over time. This should include precedent studies, material textures, and technical information, all on the same surface, allowing the drawing to evolve through multiple stages of complexity.
4. **Reinterpret with AI:** At key stages in the process, feed the evolving drawing back into the AI tool. Ask it to reimagine or reinterpret specific elements, such as the building form, landscape, or materiality. Review the AI's suggestions and selectively integrate them back into your hand-drawn work.
5. **Balance Human and Machine Input:** As the drawing progresses, focus on maintaining a balance between your manual interventions and the AI-generated reinterpretations. Ensure that the drawing reflects both human precision and machine-driven creative inputs, enriching the overall composition.
6. **Finalize the Drawing:** Once the drawing reaches its final stages, refine and unify all the layers of detail and scales into a cohesive image. This drawing should serve as a comprehensive representation of the design, incorporating the dynamic interplay of AI and human input across multiple scales and levels of detail.

⁵⁶ Frascari, 148–50.

Exercise #10: Icons

Theory: Frascari draws attention to the role of icons as powerful tools in architectural representation. Icons are not just decorative elements; they carry deep symbolic meanings that can influence how a building is perceived and understood. This exercise encourages architects to thoughtfully integrate icons into their designs, considering their cultural and historical significance.

Instruction: This exercise involves working with the concept of icons and their meaning in architecture. Frascari encourages the architect to explore the symbolic and functional roles that icons play in architectural drawings. By understanding the impact of these symbols, the architect can better communicate complex ideas and cultural meanings through their work.

The aim of this exercise is to draw the perspective of a building, building element or the interior of a room first using an inverted perspective done as watercolor and with the sky or space around (ceiling in the case of the room) rendered with silver mirror-like-paint and then to draw a plan, section and elevation of it in CAD as if the inverted perspective is a traditionally correct representation of the building or the building element.⁵⁷

Tension: The tension in this exercise arises from juxtaposing the sacred, metaphysical qualities of Orthodox icons with the secular, algorithmic processes of AI. Traditional icons transcend the material world, while AI operates within data and code, detached from spirituality. Architects must navigate the potential transformation of these icons' spiritual essence as AI reinterprets them. This exercise creates a dialogue between the divine and the digital, where the architect balances reverence with reinterpretation.

Learning Outcome: Participants will develop an advanced understanding of how digital tools can expand the symbolic and metaphysical meaning of icons in architectural design. By using AI to distort or abstract traditional icons, architects will explore how dynamic, speculative representations challenge static cultural symbols. This exercise encourages participants to rethink the role of icons in architecture – not as fixed objects, but as elements that can evolve and interact with space, time, and context in ways that are impossible in traditional media.

⁵⁷ Frascari, 165.

The exercise fosters a deeper awareness of how digital tools can create new iconographies that are fluid, responsive, and recontextualized within modern architectural practice.

Augmented Instructions:

1. **Study Traditional Icons:** Begin by researching traditional Orthodox icons, focusing on their use of inverted perspective and the symbolic significance of this metaphysical representation. Consider how these icons use space, light, and composition to convey spiritual meaning.
2. **Use AI to Explore Inverted Perspective:** Input images and descriptions of Orthodox icons into a generative AI tool to examine how the AI interprets and transforms the concept of inverted perspective. Generate new architectural representations that reflect the disorienting, anti-naturalistic qualities of these icons.
3. **Create a Watercolor or Digital Painting:** Based on one of the AI-generated images, create a watercolor or digital painting that incorporates inverted perspective. Use silver or gold leaf in the background to mimic the luminous quality of traditional iconography and enhance the metaphysical dimension of the drawing.
4. **Translate into CAD Drawings:** Once the painting is complete, translate the design into a CAD drawing, producing a plan, section, and elevation. Treat the inverted perspectives from the painting as if they are orthographically correct, adjusting the geometry and proportions accordingly.
5. **Analyze Symbolic and Spatial Relationships:** Reflect on how the use of inverted perspective, both in the painting and the CAD drawings, affects the perception of space, form, and meaning. Consider the relationship between the symbolic nature of the icons and the architectural space being represented.
6. **Iterate and Refine:** Continue refining the drawing by integrating feedback from both AI interpretations and traditional iconographic principles. Revisit the spiritual and symbolic elements of the icon to ensure that the essence of its meaning is maintained, even as the drawing evolves through digital tools.

Exercise #11: Verso-Recto

Theory: This exercise emphasizes the materiality of paper and the idea of duality in architectural drawing. By working on both sides of the sheet, architects are encouraged to consider the interconnectedness of different aspects of a design. Frascari uses this exercise to highlight how architectural drawings are not just representations but also physical objects that can convey complex, multi-layered information through their very structure.

Instruction: Explore the dual nature of architectural drawings by working on both sides of a sheet of paper. Draw a section of a building on the verso (back) of a sheet, then turn it over and draw the elevation on the recto (front), using the bled-through markings from the verso as guides. The exercise encourages the architect to think about the layered and multifaceted nature of architectural representation, treating the drawing as a physical object with its own inherent duality.⁵⁸

Tension: The tension is between the physical and the digital, between the embodied act of drawing and the immaterial nature of digital data. The AI bridges these realms, but the architect must grapple with the incompatibilities and frictions that arise when moving between them. The act of drawing becomes an exploration of the boundaries between the real and the virtual, the tangible and the ephemeral.

Learning Outcome: Participants will learn to embrace a dynamic approach to multi-layered architectural drawings by using AI to transcend the physical limits of a static medium. They will gain an understanding of how digital tools can visualize complex relationships between different scales and projections, revealing hidden connections and interactions that are often flattened or simplified in traditional drawings. This exercise encourages architects to rethink the representation of layered information, learning how digital media allows for an evolving, responsive form of architectural drawing that engages with multiple scales and dimensions in real time.

Augmented Instructions:

1. **Start with Physical Drawing:** Hand-draw a section of a building on the verso (back) of a thick, high-quality piece

of paper using ink or watercolor that will bleed slightly through to the recto (front). Focus on strong lines and textures to ensure some transfer through the paper.

2. **Digitize and Manipulate:** Scan or photograph the verso drawing to create a high-resolution digital file. Input this file into an AI tool such as Runway ML or DALL-E. Use prompts to distort, abstract, or reinterpret the original drawing, such as simulating how the drawing would appear if it were smudged, weathered, or viewed through a distorted lens.
3. **Print the AI-Modified Image:** Print the AI-modified version onto a transparency sheet or thin tracing paper. This printed sheet will act as an overlay, allowing you to manipulate the relationship between the physical drawing and the digital reinterpretation.
4. **Overlay and Interact:** Place the printed transparency over the recto (front) side of the paper. Align the transparency so that the bleed-through from the verso drawing and the AI-modified overlay interact visually. You can experiment with multiple transparencies or layers to create a rich, multi-layered composition.
5. **Iterative Adjustments:** Continue this iterative process by feeding the physical and digital drawings back into the AI tool. After each new digital manipulation, reprint the updated version, adding or subtracting elements on both the physical and digital layers. Consider drawing directly on the overlays or beneath them, ensuring an evolving, interactive composition.
6. **Finalize the Composition:** The final artifact should engage with both sides of the sheet simultaneously. Consider suspending or framing the sheet to allow light to pass through, emphasizing the dual nature of the work and the interplay between the bleed-through from the verso and the layers of transparency on the recto.

⁵⁸ Frascari, 169–72.

Reflections on Augmented Design

In these exercises, participants engage with architectural drawing not just as a static act of representation, but as a dynamic process that exists on a continuum from open, ambiguous sketches to highly precise, resolved forms. This framework, rooted in the Open-Closed Drawing Continuum, is enriched by the integration of AI, which both disrupts and enhances the ways in which architects traditionally approach the act of drawing.

AI fundamentally transforms how architects explore the open, more speculative side of the continuum. While Frascari's original exercises invite ambiguity and exploration through physical materials, the digital realm offers entirely new opportunities for speculative creation. AI allows architects to move beyond the limitations of the tangible world, creating drawings that defy material constraints and operate within abstract, evolving realms. Participants can now engage with forms, textures, and behaviors that shift, glow, dissolve, or merge in ways that are impossible with traditional media. These speculative qualities push participants to embrace uncertainty and experiment with non-linear processes of design. The introduction of AI challenges the architect to let go of control and to see what emerges from these digital tools – an approach that amplifies ambiguity and opens up new territories for creative exploration.

Yet, AI is not solely an agent of disruption; it also sharpens the precision and clarity needed to bring architectural ideas into focus on the closed end of the continuum. The digital tools used in these exercises enable iterative refinement, allowing architects to continuously test, reimagine, and perfect their drawings. AI doesn't just offer an alternative method of working – it provides a way to blur the boundaries between hand-drawn, speculative sketches and detailed, precise renderings. The fluid movement between these states of openness and closure is where the true potential of these exercises lies. The architect no longer needs to treat ambiguity and precision as opposing forces but can instead allow them to interact, feeding one into the other.

A key aspect of the learning process is the hybridization of traditional methods with AI-driven processes. These exercises demonstrate how digital tools can be integrated into existing

workflows, enhancing rather than replacing handcraft and material experimentation. By iterating between physical and digital media, participants learn to harness the best of both worlds. They understand how AI's capacity for abstraction and reinterpretation complements the architect's intuition and craftsmanship, creating a feedback loop where ideas evolve through the interplay between human and machine. This dialogue is particularly important in a world where the boundaries between physical and digital architecture are increasingly fluid.

The exercises also challenge participants to rethink their role as architects in this evolving context. AI introduces a level of unpredictability, asking architects to engage with the machine as a creative collaborator rather than simply a tool for efficiency. This tension between human intuition and machine-driven processes is central to the experience of these exercises. Participants are encouraged to navigate this relationship, developing the ability to guide, influence, and adapt to the input of AI while still maintaining authorial control. The exercises provide a space for questioning the very nature of authorship, control, and collaboration in a design process that spans the open-closed continuum.

Ultimately, these exercises cultivate a deeper understanding of how AI can augment and extend the act of architectural drawing. Participants will leave with the ability to fluidly move between speculation and precision, embracing AI's potential to challenge, enhance, and transform the way they approach design. By working within the framework of the Open-Closed Drawing Continuum, architects gain a broader toolkit for engaging with both the imaginative and the concrete aspects of architectural representation, allowing them to innovate in ways that were previously inaccessible through traditional media alone.

Conclusion

This thesis has explored the transformative role of AI within architectural drawing through the lens of the Open-Closed Drawing Continuum. By situating AI as both a disruptor and an augmentative tool, the research demonstrates that AI does not replace traditional methods but enhances them, expanding the possibilities of design practice. The continuum – ranging from open, ambiguous sketches to closed, precise drawings – provides a critical framework for understanding how AI can amplify both exploratory and refined stages of architectural representation.

The integration of AI into architectural drawing challenges long-held assumptions about authorship, creativity, and control. Through the Eleven Exercises in Augmented Design, inspired by Frascari's original pedagogical methods, this work has illustrated how AI can facilitate speculative, iterative design processes. These exercises allowed participants to explore how digital tools, far from simply automating tasks, encourage a new form of creative collaboration between human intuition and machine intelligence. Whether generating unpredictable forms, abstracting historical fragments, or pushing the boundaries of materiality, AI enables architects to rethink the limits of their practice.

Central to the thesis is the notion that AI's greatest potential lies not in perfecting what is already known, but in opening up new avenues for experimentation and conceptual development. By harnessing AI's strengths in generating variations and testing boundaries, architects can enhance their ability to explore multiple design trajectories at once. At the closed end of the continuum, AI serves to refine and clarify, supporting architects in optimizing technical precision and finalizing design outcomes.

Ultimately, this research contributes to the discourse on the evolving role of architectural drawing in the digital age. It underscores that as architects increasingly work alongside AI, the design process becomes more fluid, iterative, and collaborative. The framework provided offers a balanced approach to navigating the coexistence of human creativity and machine-driven potential, ensuring that AI enhances, rather than diminishes, the architect's role in shaping the built environment.

In conclusion, the future of architectural drawing is not a choice between the traditional and the digital, but an integration of both. By embracing the open-ended, speculative qualities of AI while maintaining the precision of manual techniques, architects can foster a richer, more innovative design process. This thesis invites architects to continue experimenting with AI as a partner in creativity, recognizing that the interplay between ambiguity and precision is where the most exciting design possibilities emerge.

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