Original Scientific Article
DOI: 10.5281/zenodo.19952464
Received: January 22, 2026; Accepted: March 24, 2026

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Architecture as Design Cognition: Synthetic Intelligence, Aesthetic Judgment, and the Operative Turn

ABSTRACT: This paper proposes design cognition as a conceptual framework for understanding architecture in the age of synthetic intelligence. Rather than framing artificial intelligence in terms of automation, efficiency, or authorship, it argues that architecture is undergoing a deeper epistemic shift: from a representational discipline to an operative cognitive practice. What is at stake is not the adoption of new tools, but a reorganisation of where and how architectural thinking itself occurs. Design cognition emerges neither within a singular human subject nor inside computational systems alone, but through distributed cognitive ecologies composed of human judgment, synthetic representations, material behaviours, and environmental processes. Drawing on computation theory, philosophy of mind, and the Agentic Architecture project exhibited at the 2025 Venice Architecture Biennale, the paper reframes creativity as the navigation of high-dimensional possibility spaces rather than expressive authorship. It introduces aesthetic cognition as an irreducible architectural capacity: an ability to perceive, project, and evaluate spatial futures that cannot be fully formalised or automated. By situating architecture within multi-scalar planetary systems, it argues that design becomes an epistemic actor capable of participating in the recomputation of material, energetic, and informational relations.

KEYWORDS: design cognition, synthetic intelligence, aesthetic judgment, architectural epistemology, distributed agency, complex systems, planetary design

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1. Introduction: Beyond Automation

The contemporary discourse on automation in architecture remains largely misaligned with the transformation it seeks to describe. Debates continue to orbit questions of efficiency, authorship, and substitution; whether machines accelerate design processes, replace human labour, or automate decision-making. While not insignificant, these concerns fail to address a more fundamental shift currently underway. What is changing is not simply how architecture is produced, but where and how architectural thinking itself takes place.

Architecture is entering a phase in which design can no longer be understood as a cognitive activity confined to the mind of a single human subject, nor as the execution of predefined rules by automated systems. Instead, architectural practice is increasingly organised around synthetic cognitive substrates—computational, material, environmental, and ecological systems that participate directly in the generation, evaluation, and transformation of spatial possibilities. The architectural automaton is neither a tool nor an autonomous subject, but a cognitive ecology: a coupled system in which intention, noise, constraint, and emergence co-produce form.

This paper argues that the decisive shift is not from human to machine agency, but from design as representation to design as cognition. Architecture becomes a mode of thinking enacted through distributed systems—human and inhuman alike—operating across scales, temporalities, and perceptual thresholds that exceed individual comprehension. Within this framework, creativity is not diminished by synthetic intelligence. On the contrary, it is intensified and displaced—relocated from expressive authorship toward the navigation of high-dimensional possibility spaces where architecture operates as an epistemic practice in its own right.

It is worth stating what this argument is not. It does not propose the disappearance of the architect, the irrelevance of authorship, or the inevitability of technical optimisation as design's horizon. These framings, which recur in both enthusiastic and critical responses to computational architecture, share a common misreading: they treat synthetic intelligence as a substitution machine rather than as an expanded cognitive field. The question is not whether machines can design, but how design intelligence is redistributed across new cognitive ecologies—and what kinds of judgment, responsibility, and imagination this redistribution enables and demands.

2. From Representation to Operation

Architecture has always been entangled with complexity. Historically, however, this entanglement has been managed primarily through representation. Drawings, diagrams, models, visualisations, and abstractions rendered complex phenomena legible to human perception. Such representations functioned as cognitive compressions: they translated vast material, social, and environmental systems into manageable visual or symbolic forms. The drawing was not simply a record of intention—it was the medium through which intention became possible.

Today, this representational paradigm reaches a limit it cannot exceed by refinement alone.

Contemporary architectural conditions are shaped by processes that resist direct depiction: climatic feedback loops, energetic gradients, algorithmic infrastructures, biological metabolisms, temporal dynamics unfolding across vastly different orders of scale. To merely represent these systems is no longer sufficient. Architecture increasingly operates within complexity rather than about it. The shift is not merely technological. It is epistemic.

This marks what might be called an operative turn. Design moves from describing complexity to constructing conditions under which complexity can be explored, negotiated, and transformed. As Luciana Parisi argues, computation operates not only as discrete calculation but as a generative and relational field capable of producing novel configurations through interaction.[1] Recursive computational workflows, algorithmic combinatorics, simulation-driven synthesis, and multi-scalar modelling do not simply visualise systems; they actively participate in their evolution. Architecture becomes less a mirror of the world and more a synthetic environment in which new configurations can be tested and brought into being.

The operative turn also alters the temporality of design. Instead of a linear sequence in which analysis precedes form and performance is tested after the fact, design becomes recursive. Simulation, evaluation, and generation feed back into one another. Form is no longer an endpoint but a

[1] L. Parisi, *Contagious Architecture: Computation, Aesthetics, and Space*, MIT Press, Cambridge, Mass., 2013. Parisi's account of algorithmic computation as a generative and relational field—capable of producing novelty through interaction rather than through the execution of fixed rules—provides theoretical grounding for the operative turn described in this paper.

temporary crystallisation within a continuous field of negotiation. Representation does not disappear in this condition—it becomes one operative layer among many, participating in cognition rather than concluding it.

A further consequence concerns the invisible. Much of what shapes the built environment—microclimatic flows, energetic exchanges, biochemical processes, algorithmic operations—remains inaccessible to unaided perception. Synthetic intelligence enables these invisible dynamics to become operational: to be sensed, inferred, simulated, and transformed into generative dimensions of design. Forces that were once treated as background—pressure gradients, thermal differentials, wave dynamics—become primary materials. Architecture extends beyond the limits of the human sensorium not by abandoning legibility, but by developing new instruments for perceiving and acting within what was previously opaque.

3. Synthetic Design Cognition and the Extended Mind

If architecture is no longer primarily representational, the central question becomes: where does design thinking now occur?

Design cognition, as it emerges today, cannot be located exclusively in the mind of the architect, nor attributed solely to computational systems. It arises through recursive coupling between human intention, synthetic representations, and evaluative processes distributed across multiple agents and substrates. This is not a metaphor. It is a structural description of how contemporary architectural practice actually works.

Andy Clark and David Chalmers proposed that cognitive processes do not end at the boundary of the brain—or even the body.[23] When external resources are reliably available, actively used, and directly coupled to action, they function as genuine components of a cognitive system rather than mere aids to it. What changes with synthetic intelligence is not the principle—architecture has always extended cognition into

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[2] A. Clark, D. Chalmers, "The Extended Mind," *Analysis*, 58, 1, 1998, 7–19. Clark and Chalmers argue that cognitive processes extend beyond the brain into the environment when external resources are reliably coupled to action. Architecture's long history of externalising cognition into drawings and models finds its theoretical extension here: computational environments are not aids to thought but components of it.

[3] M. Polanyi, *The Tacit Dimension*, Doubleday, New York, 1966, p. 4. Polanyi's formulation describes the condition of skilled practice in which recognition precedes articulation. Aesthetic cognition in architecture operates within exactly this structure—and is intensified, not replaced, by the expansion of synthetic design environments.

drawings and models—but the scale, resolution, and generative capacity of the extension. Latent computational spaces, surrogate models, optimisation engines, and feedback-driven simulations do not assist thought; they constitute a new cognitive terrain. Within this terrain, design decisions are not linearly authored but iteratively negotiated. Possibilities are generated, perturbed, filtered, and recombined through processes that exceed explicit articulation.

Michael Polanyi's observation that *we know more than we can tell* acquires new architectural significance here. Synthetic design cognition unfolds through exactly this condition: computational systems produce fields of possibility that are not simply chosen from, but navigated. The designer operates within these systems—steering, discovering, filtering, committing to trajectories—exercising a kind of tacit intelligence that is trained and situated even when it cannot be fully verbalised. Cognition becomes distributed across an ecology of generation and judgment.

Crucially, noise plays a constitutive role in this ecology. Stochastic variation, probabilistic inference, and algorithmic drift introduce productive instability into design processes. Noise is not an error to be eliminated but a generative force that enables exploration beyond established patterns and deterministic solutions. It resists premature closure and allows novel spatial and organisational configurations to emerge. Environmental logics, material constraints, and programmatic relations do not converge neatly. They interfere, overlap, and pull in different directions. Synthetic design cognition operates within this field of negotiated indeterminacy—and thrives there.

4. Aesthetic Cognition: The Irreducible Capacity

Within this expanded cognitive field, traditional notions of authorship become inadequate—not because the architect disappears, but because the architecture of authorship itself must be rethought. The architect as singular creative origin gives way to a distributed assemblage of contributors: computational agents, material behaviours, environmental forces, algorithmic logics. Agency is no longer centralised but dispersed across interacting systems.

Yet, this redistribution of agency does not imply the disappearance of human creativity. What remains irreducible is not authorship as ownership, but judgment as a cultivated capacity for evaluating meaning, coherence, and consequence in the absence of fully defined rules.

This claim requires defence. The proliferation of generative AI tools—diffusion models, image synthesis systems trained on vast architectural datasets—might seem to challenge it. If machines can generate images that are aesthetically convincing, that audiences find beautiful or spatially compelling, does this not demonstrate that aesthetic judgment can be formalised and reproduced computationally?

The answer, grounded in both theoretical argument and practical experience working within these systems, is no—and the reason matters. What diffusion models produce at scale is a sophisticated statistical average of existing aesthetic preferences. They are extraordinarily powerful instruments for finding the centre of a distribution: the most likely form, the most recognisable style, the image that satisfies the largest number of trained expectations simultaneously. This is precisely why AI-generated architectural imagery so rapidly converges on a particular generic quality—technically proficient, spatially plausible, aesthetically familiar, culturally inert. It is fluent in the known. It is structurally incapable of the genuinely unfamiliar. This is AI slop at civilisational scale: a proliferation of competent averages mistaken for creative output.

Aesthetic cognition in architecture is not the ability to satisfy existing preferences. It is the capacity to perceive latent order within configurations that have no prior typological grounding—to recognise coherence before it is legible, to anticipate spatial logic before it is formalised, to commit to a trajectory whose destination is not yet visible. This is not intuition in the romantic sense. It is a trained, historically situated, practically grounded capacity that operates at the edge of what can be verified. It is precisely what the practitioner does in the gap between what the system generates and what the work becomes.

Working within expanded design search—navigating high-dimensional generative fields, filtering vast combinatorial outputs, recognising which configurations carry genuine architectural force—makes this capacity more demanding, not less. The architect operating within synthetic systems is not relieved of aesthetic judgment by computational assistance. She is placed in a position where that judgment must operate faster, across a wider field, and with higher stakes than conventional practice requires. The system expands the space of possibilities; it does not select among them. That selection—that commitment to a trajectory rather than another—remains irreducibly human, and irreducibly difficult.

This is also the distinction between design cognition and mere design generation. Generation is abundant; it costs almost nothing to produce

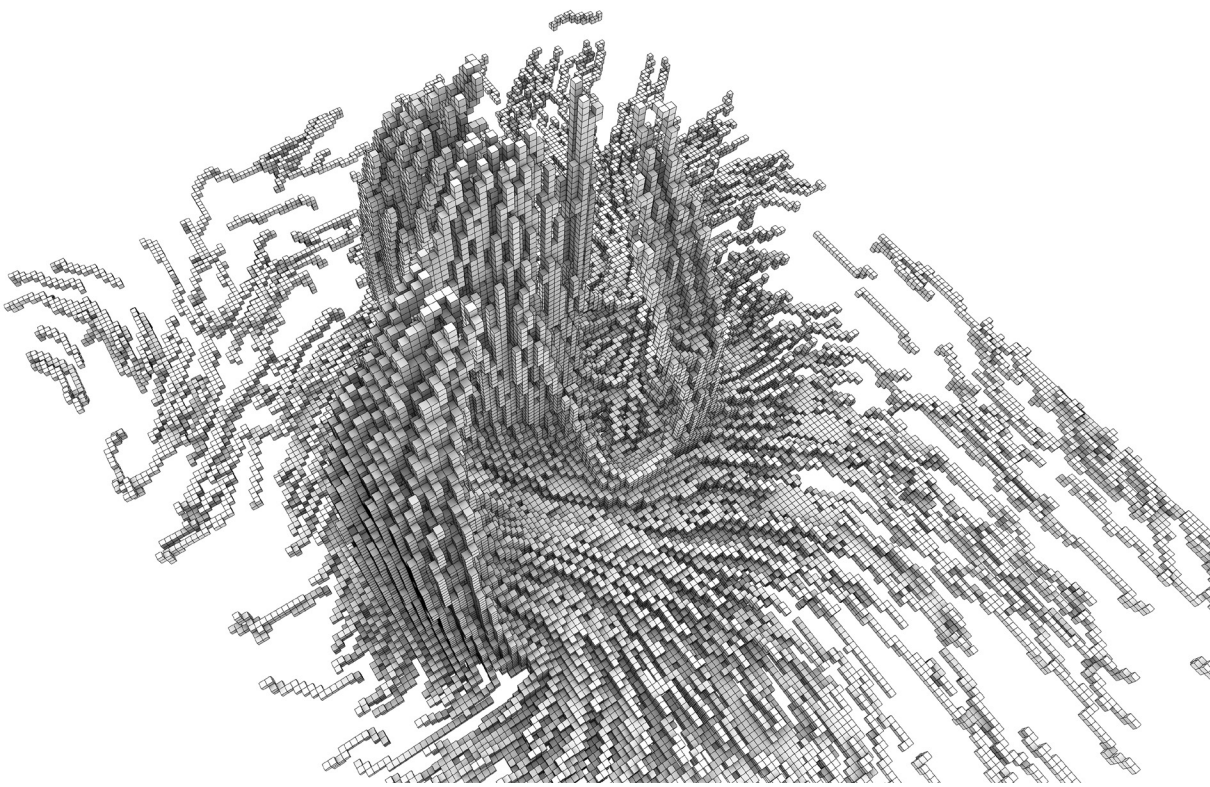

Figure 1. Alisa Andrasek, *Agentic Architecture*, implemented design search system. Courtesy of the author. High-resolution voxel substrate, environmental field simulations, and multi-objective agents operate as a generative field. Environmental exposure, spatial adjacency, material logic, and programmatic gradients are negotiated simultaneously, producing site-specific massing, vertical ecology, and discrete AI Timber assemblies within a coherent system.

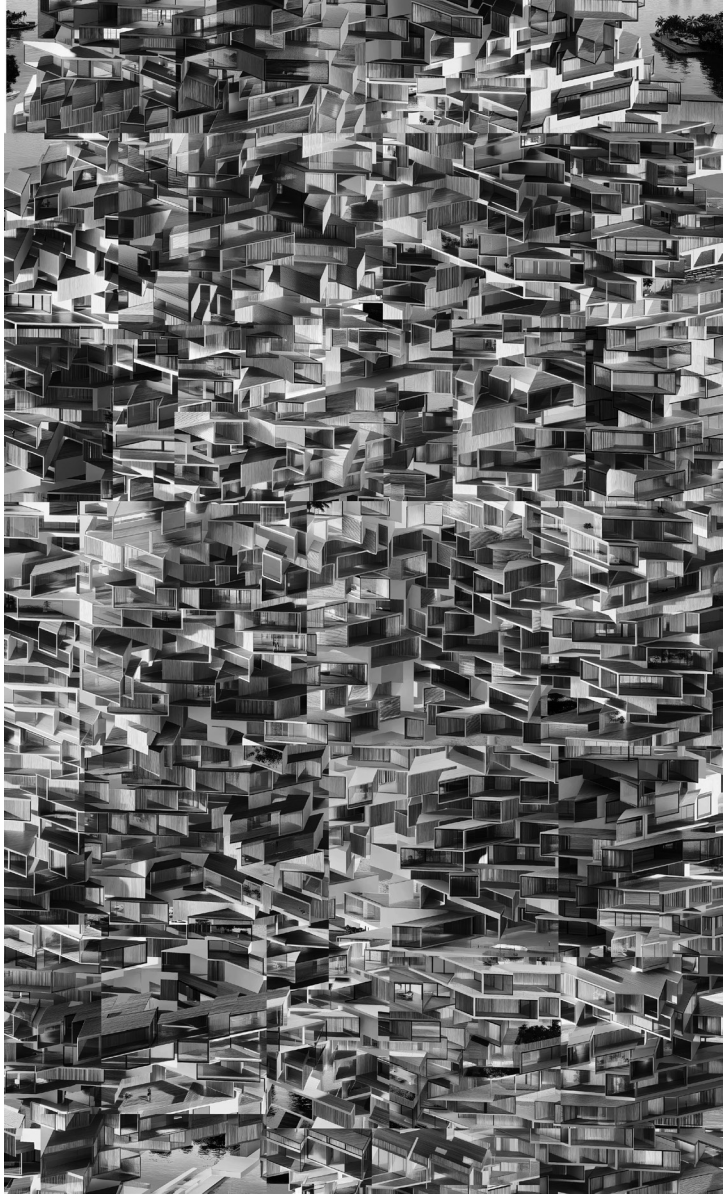

Figure 2. Alisa Andrasek, *Vertical field typology: superimposed architectural states*. Courtesy of the author. Discretised timber and glass assemblies generated through AI-driven combinatorics and environmental imprinting. Representation unfolds as a field of coexisting architectural configurations, expressing multiplicity intrinsic to design search.

a thousand variants. Cognition—the ability to know which of those thousand variants is worth pursuing, and why, and what it opens—is scarce. It is where the practice lives.

5. Agentic Architecture: Design Cognition in Practice

These claims are operative in practice. The Agentic Architecture project, developed for the *Intelligens* exhibition at the 2025 Venice Architecture Biennale, acts as a demonstrator of design cognition as a distributed, synthetic process—and as a test of these arguments against the resistance of an actual site, with actual material, environmental, and tectonic constraints.[4]

Curated by Carlo Ratti under the theme *Intelligens: Natural, Artificial, Collective*, the Biennale sought to explore new forms of intelligence emerging from the convergence of planetary systems, technological processes, and collective agency. Agentic Architecture was conceived as a direct response: positioning architecture itself as a form of collective intelligence—not as a claim about institutional scale, but as an argument about how design can organise relations among human, nonhuman, and environmental actors within a shared generative framework.

The project is situated in Miami's volatile coastal ecology: rising sea levels, storm surge, extreme heat and humidity, and intensifying pressures on high-density collective living. Rather than treating these as constraints to be mitigated after the fact, the site is operationalised as part of the project's deep ecology. Environmental forces—wind, water, solar exposure, views—participate directly in architectural formation. They are not analysed and then applied. They enter the generative field from the outset.

The design process begins by voxelising site data, producing a high-resolution substrate capable of hosting multiple interacting datasets. An electromagnetic field simulation establishes macroscale organisational logic through which site determinants interact. The resulting massing exhibits spiral and torsional tendencies arising from first-principles interactions among context-specific vectors: orientation, solar exposure, views, wind patterns, wave dynamics. A multi-agent system is then deployed within this re-voxelised field—introducing stochastics, local negotiation, and high-resolution differentiation. These agents are

[4] A. Andrasek, "Agentic Architecture: Synthesising Complexity for Regenerative Futures," Exhibition *Intelligens. Natural. Artificial. Collective.*, curated by Carlo Ratti. 19th International Architecture Exhibition—La Biennale di Venezia, Venice, 2025.

structured as multi-objective actors, negotiating overlapping and sometimes competing criteria: environmental exposure, spatial adjacency, material logic, and the connective vector logics of prefabricated elements.

The architect operates within this field by searching for emergent expressions and aesthetics—exercising agency through pattern recognition rather than prescribing outcomes. Within a combinatorially vast and rapidly evolving field, aesthetic cognition must move faster than articulation, committing to trajectories before their consequences are fully known. Judgment and generation are simultaneous rather than sequential. This is the practice of design cognition in its most concentrated form.

Water is present from the outset as a primary design agent. The building's lower condition—its wet feet—develops as a high-resolution field of differentiated pylon foundations, piers, and boardwalks: not a repetitive substructure supporting an independent object, but a distributed interface through which hydrological pressures are absorbed, scattered, and neutralised. The logic draws on mangrove root systems, where resistance is achieved through intricacy, redundancy, and distribution rather than mass. Architecture here does not oppose environmental force—it resolves force through organisation.

Air operates in continuity with this hydrology. External wind forces inform the depth, porosity, and differentiation of the building skin. Internally, Miami's hot and humid climate drives a multiplied chimney effect: a dense network of vertical air channels and connective voids generating internal airflow and passive cooling. The building develops its own internal weather. What is typically treated as invisible background—pressure gradients, thermal difference, airflow—enters directly into architectural formation.

The material system through which this becomes constructable is AI Timber: a research trajectory linking discrete timber systems with computational design and machine-learning-driven combinatorics. Timber joints operate as structural, geometric, and computational agents. Their vector-based connection logic allows large families of differentiated assemblies to emerge from a shared set of discrete elements—enabling prefabricated timber to move beyond repetition and standardisation, producing heterogeneous, context-sensitive architecture that remains fully buildable.

The resulting vertical organisation does not align with established typologies. It operates as a vertical field—a complex built ecology structured through gradients of light, exposure, ventilation, and protection.

Space is organised through environmental and performative intensities rather than through the repetition of floor plates. What emerges cannot be named with existing terminology. It is not a tower. It is not infrastructure. It is a yet-to-be-named typology, legible only through the logic of its own formation.

Representation is integral to this process. Quantum render does not function as a final visualisation layer but as an operative mode of seeing the system—rendering architecture as a field of gradients, porosities, and environmental effects, where material and atmosphere are inseparable. The project exists as a superposed field of architectural states rather than a singular resolved image. Representation sustains openness rather than closure, and participates in design cognition rather than following it.

6. Scale, Invisibility, and the Limits of Perception

A further consequence of synthetic design cognition concerns its relationship to scale. Architectural practice has historically operated within dimensions legible to human perception. Contemporary design increasingly engages phenomena unfolding across vastly different registers: micro-material assemblies, atmospheric systems, digital infrastructures, planetary cycles.

Many of the forces shaping architectural environments remain imperceptible: data flows, energy exchanges, biochemical processes, algorithmic operations. Synthetic intelligence enables these invisible dynamics to become operational—allowing forces, flows, and fields to participate directly in design logic and to crystallise into legible spatial and aesthetic structures. In doing so, architecture extends beyond the limits of the human sensorium without abandoning the requirement for spatial and material coherence.

Time becomes elastic within this expanded field, accommodating geological durations alongside real-time feedback. Space becomes relational, defined by gradients and fields rather than discrete objects. Scale ceases to be a fixed category and becomes an adjustable parameter within design cognition. These are not rhetorical expansions but actual operations: the voxelised site model, the electromagnetic field simulation, the multi-agent system, the fluid-dynamic analysis—each engages a different temporal and spatial register, contributing to an architectural outcome unreachable by any single register alone.

7. Planetary Design Cognition: Systemic Intervention at Scale

The convergence of these transformations situates architecture within a broader planetary context. But the term planetary requires precision. It does not mean that every project addresses global systems, or that architecture should aspire to the scale of infrastructure policy. It means something more specific and more tractable: that architectural thinking can identify systemic problems embedded in the built environment at civilisational scale, intervene at the level of their underlying logic, and propagate solutions that are replicable, adaptable, and genuinely consequential.

One of the most persistent and underacknowledged of these systemic problems is the monotony of prefabricated architecture. For decades, the industrialisation of building production has delivered efficiency at the cost of differentiation. Prefab systems close down the combinatorial possibilities of construction in the name of standardisation, producing environments that are technically adequate and spatially impoverished—unloved buildings at a planetary scale. This is not a cosmetic failure. It is a structural one: the logic of the system produces uniformity as a necessary output, and the resulting environments fail precisely because they are not loved.

AI Timber proposes an intervention at exactly this level. The connector—the joint—is where the combinatorial logic of prefabricated construction is either closed down or opened up. Conventional prefab fixes the joint geometry, which fixes the assembly logic, which fixes the spatial possibilities of the resulting buildings. AI Timber applies vector mathematics to joint geometry, transforming each connection from a fixed constraint into a combinatorial agent. The result is a system that retains the economic and environmental advantages of prefabrication—standardised elements, rapid assembly, material efficiency—while recovering the spatial richness and differentiation that prefab has historically foreclosed.

This is what it means to work at a planetary scale without grandiosity: to identify the exact point in a system where a precise intervention unlocks consequences that propagate outward. The connector is humble. Its implications are not. If timber prefabrication is to be deployed at the scale the climate crisis demands—replacing concrete and steel globally, absorbing carbon, enabling rapid and affordable housing in regions that need it most—then the quality of the environments it produces is not an aesthetic preference. It is a condition of whether people will accept,

inhabit, and maintain what is built. Democratising good design is not a luxury aspiration layered on top of real problems. It is constitutive of any solution to them.

Agentic Architecture is a pilot for this logic, not a singular building. The design system it embodies—environmental forces as generative inputs, discrete material elements as combinatorial agents, multi-objective search across high-dimensional fields, aesthetic cognition as the irreducible filter—is transferable. It is a methodology before it is a building. The Miami project demonstrates what the system can do under specific coastal conditions; the same framework is applicable to high-density urban infill, to post-disaster reconstruction in climate-vulnerable regions, to the urgent global problem of affordable housing that is also spatially dignified. The planetary claim is grounded in exactly this replicability.

But replicability alone is not the argument. What the methodology also produces—and what matters as much as its transferability—is a genuinely new aesthetic: spatial experiences of wonder and awe that could not have been designed by any other means, because they could not have been imagined by any other means. They emerge from the logic of the system itself, from the interaction of environmental forces, material combinatorics, and the architect's sustained act of recognition within a generative field. This is not aesthetics as surface or style. It is form that carries the intelligence of its own making, spatial sequences whose richness is inseparable from the epistemic process that produced them.

This distinction matters because aesthetic cognition—the trained, irreducible capacity to know which configuration carries force and which is merely generated—is not an automatic consequence of access to powerful tools. The methodology described here is accountable to both dimensions simultaneously: it must operate at a planetary scale, and it must produce environments worth inhabiting, worth experiencing, worthy of being called architecture. These demands are not in tension. Each is the condition of the other.

8. From Typology to Field

As architectural cognition shifts, established typologies begin to dissolve—not because classification is impossible, but because the logics that generated historical types are no longer the primary drivers of form. Buildings emerging from the entanglement of environmental dynamics, generative computation, human judgment, and multispecies inhabitation resist

classification as tower, block, or infrastructure. Their logic is not static but relational, evolving over time in response to changing conditions.

Architecture increasingly takes the form of emergent assemblages: spatial organisations arising from the interaction of discrete agents, stochastic processes, and ecological relations, rather than from fixed programmes. Gilbert Simondon's account of individuation is instructive here: form, in his framework, does not pre-exist the process that produces it but emerges through the resolution of tensions within a field of pre-individual potentials.[5] What Agentic Architecture demonstrates operates by exactly this logic. When design is organised as a search process within a generative field, outcomes genuinely exceed available typological categories not by chance but by necessity—because the process is oriented toward configurations that existing categories have not yet stabilised. The indeterminacy is procedural rather than rhetorical.

The move from typology to field does not signal the end of architectural form, but its redefinition. Form becomes provisional, contingent, and responsive—an emergent property of cognitive processes distributed across systems. Architectural language must evolve accordingly, developing concepts capable of articulating these dynamic conditions without either celebrating indeterminacy as an aesthetic value in itself or retreating to the false clarity of resolved objects.

9. Conclusion: What Remains Open

Architecture, as it emerges through synthetic intelligence, is no longer defined primarily by objects or images. It is defined by its capacity to think through systems, through materials, through time. Design cognition becomes a distributed, synthetic process in which human and inhuman agencies co-evolve—not toward a predetermined resolution, but through sustained engagement with complexity as a medium.

The arguments assembled here—the operative turn, the extended cognitive field, the irreducibility of aesthetic judgment, the systemic logic of planetary intervention—converge on a single claim: that architecture is currently undergoing an epistemic transformation more fundamental

[5] G. Simondon, *Individuation in Light of Notions of Form and Information*, University of Minnesota Press Minneapolis, 2020. Simondon's account of individuation as a process of resolving pre-individual tensions within a metastable field—rather than the instantiation of a pre-given form—offers a rigorous philosophical basis for understanding how architectural form can emerge through generative processes without being prescribed by them.

than any shift in style, technology, or professional organisation. What is changing is not the appearance of architecture but its nature as a cognitive practice. This transformation is already underway in work that does not yet have an adequate theoretical account of itself. This paper is an attempt at that account.

But it would be a mistake to end on resolution. The framework proposed here opens at least as many problems as it closes, and those problems are more interesting than the conclusions.

If aesthetic cognition is irreducible—if the capacity to recognise latent order within a field of possibilities cannot be formalised without loss—then it remains genuinely unclear how this capacity is transmitted, cultivated, or shared. Design education has never had a satisfactory account of how aesthetic judgment develops; for most of its history, it could pretend the question was answered by the master-apprentice relation or by the authority of established taste. Neither answer is available now. Synthetic intelligence floods every practitioner with more generated possibilities than any previous generation of architects encountered in a career. The question of how to train the eye—the real eye, the one that knows what it is looking for before it can say—becomes urgent in a new way.

If the planetary claim is genuine—if architecture can identify systemic leverage points and propagate solutions at civilisational scale—then the profession faces a question it has largely deferred: what obligations follow from that capacity? The ability to democratise good design is not the same as the will to do so. Synthetic cognition, deployed within existing economic structures, is perfectly capable of concentrating spatial quality further rather than distributing it. The tools do not determine the direction.

And if design cognition is genuinely distributed—if thinking happens across the coupled system of human judgment and synthetic process rather than within either alone—then the boundary of the work is no longer clear. The building is a crystallisation, not a completion. The design system that generated it continues to exist, continues to be navigable, continues to produce states that were not reached. The work is always in-formation.

Perhaps this is the most honest thing that can be said about architecture in the age of synthetic intelligence: it is a practice that has become capable of generating more futures than it can pursue, and the question of which futures are worth building—and for whom—has never been more open, or more consequential.

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