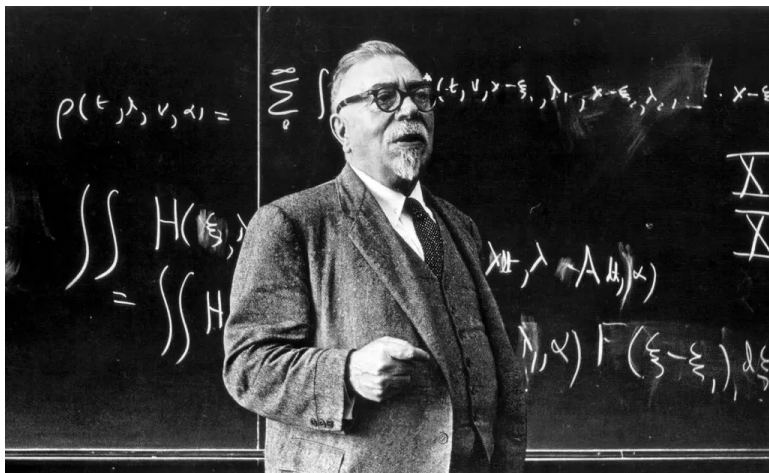


Dub Langlands: Art Theory Texts on Cybernetics

by Eric Schmid



Graham Vunderink Gallery
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First Edition

Dedication

For Alyssa Van Denburg

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Contents

Introduction	viii
0.1 Intersecting Cybernetics and Contemporary Art	viii
0.2 Mathematical Formalism Meets Philosophical Modeling	viii
0.3 Epistemological and Structural Constraints in Art and Technology	ix
0.4 Phenomenology, Structuralism, and Cybernetic Capitalism	x
0.5 Engaging Key Thinkers and the Discourse on Abstraction	xii
0.6 Towards a New Synthesis of Art and Logic	xiii
 1 On Contemporary Art and Experimental Music	 1
1.1 Introduction	1
1.2 The Market Emperor’s New Clothes	2
1.3 The Solipsistic Hermit and the Collapse of Insular Art	4
1.4 Art’s Social Paradox: Nomadic Elites and the Illusion of Quality	6
1.5 Cybernetic Capitalism: Identity and the Financialization of Creativity	8
1.6 Navigating the Paradox: Beyond Co-optation or Impotence	10
 2 Categorical Cybernetics: A Framework for Computational Dialectics	 14
2.1 Introduction	14

2.2	The Dialectics of Adjointness	15
2.3	Bayesian Open Games and Computational Implementation	17
2.4	Self-Reference and Fixed Points	18
2.5	Implementation Through Dependent Types	20
2.6	The Emergence of Control: A Categorical Cybernetics Perspective	21
2.7	Performance and Scalability	23
2.8	Conclusion	23
3	<i>Treatise on Intuitionistic Type Theory</i> by Johan Georg Granström	25
3.1	Introduction	25
3.2	Kantian Foundations	26
3.2.1	Constructive Nature	27
3.2.2	Forms of Judgment	28
3.2.3	Pure Intuition and Type Formation	29
3.3	Phenomenological Insights	30
3.3.1	Meaning Explanations	30
3.3.2	Types as Intentions	31
3.3.3	Evidence and Truth	32
3.4	The Brouwer-Hilbert Debate Revisited	33
3.4.1	Law of Excluded Middle	33
3.4.2	Formal vs. Contentful Mathematics	34
3.4.3	The Role of Proof	35
3.5	Contemporary Relevance	36
3.5.1	Computer Science	36
3.5.2	Foundations of Mathematics	37
3.5.3	Future Directions	38
3.6	Critical Assessment	40
3.6.1	Technical Details	40
3.6.2	Historical Context	41
3.6.3	Practical Applications	42
3.7	Conclusion	43
4	The Limits of Formalization: Mathematics, AI, and Human Creativity	44

4.1	Introduction	45
4.2	The Technical Foundations of Modern Power	45
4.3	Paths Forward: Formalization and Its Alternatives	46
4.4	The Limits of Artificial Intelligence	47
4.5	The Black Box of Understanding	47
4.6	Conclusion	48
5	Toward a New Cybernetic System:	
	The Dance Between Abstract and Concrete	50
5.1	The Architecture of Thought	51
5.2	The Material Ground	51
5.3	Two Subjects, One System	52
5.3.1	Gerald Donald and the Afrofuturist Vision	52
5.3.2	Helena Hauff and Technological Ambivalence	53
5.4	The Direct Sum and Its Implications	53
5.4.1	Mathematical Formalization	53
5.4.2	Toward the Real and Ideal	53
5.4.3	Engineering Poetic Reality	54
5.5	The Role of Technology	54
5.5.1	The Digital Interface	54
5.6	Grace and the Void	55
5.6.1	The Role of Desire	55
5.7	The Cybernetic Resolution	55
5.8	Practical Implications	56
5.8.1	Artistic Practice	56
5.8.2	Theoretical Construction	56
5.9	Conclusion	56
6	Toy Philosophy Universes: On Philosophical Modeling Through Contemporary Art	58
6.1	Exhibition	58
6.2	Artist Practices	59
6.2.1	Valerie Keane	59
6.2.2	Asha Sheshadri	60

6.2.3	Tim Pierson	60
6.2.4	Giangiacomo Rossetti	61
6.2.5	Bedros Yeretjian	61
6.2.6	Max Guy	62
6.2.7	Lauren Burns-Coady	62
6.3	Toy Philosophy Universes	62
6.4	Publisher in Residence	63
7	Mathematics as Metaphysical and Construc-	
	tive	64
7.1	Weil, Grothendieck and Mac Lane	64
7.2	Grothendieck Universes and Category/Topos	
	Theory	66
	Bibliography	68
	Author Biography	73

Introduction

Intersecting Cybernetics and Contemporary Art

Dub Langlands: Art Theory Texts on Cybernetics assembles a series of essays that interrogate the fertile intersection of cybernetics and contemporary art. At its core, this collection explores how feedback systems, control mechanisms, and informational paradigms – concepts first articulated by Norbert Wiener’s cybernetics – refract through the lens of today’s artistic and cultural practices. In these essays, art is not treated as an isolated aesthetic realm but as a complex system entangled with technology and logic, subject to feedback loops of meaning and influence. Drawing on Wiener’s insight that communication systems can suffer a “malady of content” when signals circulate without substance, the author examines how creative culture can retain its substance in an age of self-regulating networks and algorithmic reproduction. The result is a rigorous inquiry into art as a cybernetic system – one that produces new meanings through dynamic interaction between artist, audience, and machinic processes.

Mathematical Formalism Meets Philosophical Modeling

Running in parallel with its cybernetic inquiries, the book engages deeply with mathematical formalism and philosophical modeling as tools for understanding art and knowledge. The title’s evocation of “Langlands” is apt: the Langlands program in mathematics famously seeks unifying patterns across algebra and geometry, and here it serves as a metaphor for unifying disparate domains of thought. The essays draw analogies between the abstract universality of advanced mathematics and the structural ambitions of contemporary theory.

In the spirit of mathematician-philosopher Gilles Châtelet, who explored “the articulation between mathematics and physical reality, between algebra and geometry, between the operations of a finite being and the manifestations of nature”, this collection asks how abstract formalisms can map onto, or model, lived experience and artistic creation. The author treats philosophical concepts as models – not unlike mathematical models – that attempt to capture the essence of phenomena. By doing so, the text bridges domains that are usually kept separate: it brings formal logic and algebraic thinking into dialogue with the phenomenology of art, and it uses artistic imagination to illuminate formal structures. This mutual modeling reveals that abstraction is not anathema to experience but a tool to deepen it – a view resonant with Reza Negarestani’s claim that abstraction originates in a “dialectic between form (mathematics) and sensible matter (physics)”. In other words, our most rarefied ideas are born from the interplay between systematic form and the flux of reality. Throughout these essays, mathematical ideas (from topology to algorithmic logic) appear as potent metaphors and frameworks for art and philosophy, demonstrating a commitment to systematization in thinking that does not negate creativity but rather enables new forms of it.

Epistemological and Structural Constraints in Art and Technology

A unifying critical stance of the book is its interrogation of the epistemological and structural constraints that undergird art, technology, and logic. Epistemology — the study of knowledge — here concerns not only what we know about art and technological systems, but how we come to know it, and what limits that knowledge. The essays ask pointed questions: How do algorithms and formal rules shape what can be expressed or perceived in art? In what ways do our tools of knowledge (from mathematical languages to digital interfaces) enable certain creative possibilities while foreclos-

ing others? Such questions recall the structuralist insight that beneath cultural expressions lie deep codes and structures; indeed, one could view the institutional frameworks of art or the architectures of software as analogous to a language that artists and users must “speak.” By probing these underlying structures, the author reveals the often-invisible logics that both enable and constrain creative thought. There is a continual tension between freedom and framework: just as a grammar allows novel sentences but limits what can be said, the formal systems in art and tech allow innovation yet also set bounds. The book’s critical investigation aligns with a structuralist approach to culture, yet it is tempered by a phenomenological sensitivity to lived experience — an awareness that behind every structure stands a human consciousness navigating and sometimes resisting it. In mapping out these constraints, the essays also reflect on the price of systematization: for instance, when every artwork is archived as data or every aesthetic choice is premediated by software, do we risk reducing art to mere input-output devoid of human aura? Here the specter of cybernetic capitalism looms: a scenario in which artistic and intellectual life are subsumed under the imperative of efficient information-processing and exchange. This collection grapples with that scenario, scrutinizing the fine line between using structures and being used by structures.

Phenomenology, Structuralism, and Cybernetic Capitalism

While steeped in contemporary issues, the essays consciously situate themselves within broader intellectual traditions. Phenomenology provides one key backdrop: the author invokes the legacy of thinkers like Edmund Husserl and Maurice Merleau-Ponty to foreground the importance of first-person experience and perception in any discussion of art or technology. By doing so, the text ensures that amidst all the talk of systems and abstractions, the human perspective — the way things

appear to us, the lived experience of interacting with machines or viewing art — remains central. In parallel, the influence of structuralism is evident in the book's systematic approach to culture and knowledge. Just as structuralist anthropology or linguistics sought the hidden structures governing myths or language, here the author seeks the hidden informational and logical structures shaping art practices and techno-scientific discourse. This structuralist lens helps frame art and technology as governed by codes (visual, linguistic, digital) that can be decoded and critiqued. Yet, the book also acknowledges the evolution from classical structuralism into what one might call cybernetic structuralism: the recognition that structures today are often dynamic, recursive, and self-regulating. This brings us to the notion of cybernetic capitalism, a concept underpinning the collection's social and political analysis. Following theorists like the collective Tiqqun, the book understands late capitalism itself as a cybernetic system — “an emerging social formation that has taken over from Fordist capitalism,” essentially the application of feedback and information theory to political economy. In this view, markets, media, and even subjectivity form a vast self-regulating network geared toward endless accumulation and control. By engaging with this idea, the essays position themselves to critique how contemporary capitalism leverages technology and abstraction as instruments of power. The text resonates with Gilles Châtelet's scathing critique of market-driven cybernetics: under neoliberal technocracy, “all fresh meat, all fresh brains, must become quantifiable and marketable”. Such insights from Châtelet underscore the stakes of the discussion — namely, the risk that human creativity and thought could be instrumentalized as mere resources in a grand information-market system. The book grapples with this tension, positioning itself in opposition to the reduction of art and knowledge to cold calculability. In aligning phenomenological critique (which humanizes and particularizes experience) with structural analysis (which demystifies the systems we inhabit), the collection

carves out a space to question the current technocratic order — what philosopher Reza Negarestani and others might call the regime of techno-rationality that dominates our era.

Engaging Key Thinkers and the Discourse on Abstraction

Throughout the essays that follow, readers will find engagements with key thinkers who have tackled the entanglements of art, science, and systems. Norbert Wiener looms large as the originator of cybernetic theory; his pioneering ideas on feedback, communication, and control provide a conceptual vocabulary that the author both utilizes and questions. By revisiting Wiener’s work, the book situates itself in a lineage of inquiry into how humans and machines interact, and how information circulates. For instance, Wiener’s warning about the emptiness of content in an over-mediated society becomes a springboard for examining today’s digital art circulation and the attention economy. Moving forward in time, the text dialogues with Gilles Châtelet, whose dual identity as mathematician and philosopher makes him a patron saint of this project. Châtelet’s influence is palpable in the way the essays oscillate between mathematical rigor and political passion. His notion of “cyber-livestock” — humanity corralled by the forces of quantification and market logic— is a provocative image that echoes throughout the book’s critique of cybernetic capitalism. By invoking Châtelet, the author aligns with a tradition that refuses to let abstract mathematics and concrete politics live in separate worlds. Finally, the presence of Reza Negarestani’s thought signals the collection’s engagement with the contemporary philosophical discourse on abstraction and system-building. Negarestani, a philosopher known for bridging continental theory with formal sciences, argues that the true power of art and philosophy lies in their ability to rigorously abstract – to construct concepts and systems that have real explanatory force. In one essay, Negarestani asserts that “the task of art is rediscovered not in its ostensible autonomy but in its singular power

to rearrange and destabilize the configurational relations between parameters of thought, ... imagination and material constraints". This insight, which the book takes to heart, encapsulates the collection's ethos: art's highest calling is not to remain a closed aesthetic sphere, but to act as a catalyst that reconfigures how we think, perceive, and live. By engaging figures like Wiener, Châtelet, and Negarestani, the essays position themselves within an ongoing discourse on the role of abstraction and systematization in both artistic and mathematical thought. They contribute to a conversation that spans decades – from mid-20th-century cyberneticians, through late 20th-century structuralists and critical theorists, to 21st-century speculative thinkers – all grappling with how abstract structures can both trap and liberate us.

Towards a New Synthesis of Art and Logic

In its ambition and scope, Dub Langlands encourages us to see contemporary art and theory as part of a grand continuum of knowledge – one that includes scientific paradigms and philosophical traditions, yet also challenges them. The book frames the collection as more than a set of isolated essays: it is an intellectual expedition across domains, always returning to fundamental questions about creation, understanding, and control. By interrogating the limits of formalization and the possibilities of experimentation, the author prompts readers to reflect on their own position within these systems. Are we merely subjects of a cybernetic capitalist order, or can we harness abstraction and feedback to spur new modes of freedom and meaning? In posing such questions, this book joins an ongoing dialogue about what art does in an age increasingly governed by algorithms, data, and models. It stands at the crossroads of phenomenology and cybernetics, of structure and experience, suggesting that only by crossing those apparent divides can we fully grasp the challenges and potentials of our time. Dub Langlands: Art Theory Texts on Cybernetics thus serves as both a crit-

ical mirror and a creative map – reflecting the constraints of our present intellectual condition, while charting pathways toward a future where art, technology, and logic co-evolve in more liberating and imaginative forms.

On Contemporary Art and Experimental Music

We are not stuff that abides, but patterns
that perpetuate themselves. A pattern is a
message, and may be transmitted as a
message.

— Norbert Wiener

Introduction

Contemporary art often finds itself pulled between two extremes: on one end, artists chase market success and institutional validation; on the other, artists reject these systems to pursue an isolated, inward vision. These poles can be characterized as the emperor with no clothes versus the hermit in a self-made tower. In the first case, a market-lauded artist may be like an emperor in invisible finery – tricking galleries, collectors, and followers into accepting work that is effectively empty or purely fashionable as if it were profound. In the second case, a solipsistic artist might pridefully shun the art world’s social marketplace, only to produce work so insular and self-indulgent that it collapses under the weight of its own isolation. This essay explores the spectrum between these two positions, drawing on themes from Dimes is of the

Essence and Ultrablack of Music: Market Alibis. In doing so, we confront a shared paradox: both the market charlatan and the hermetic rebel complain about the social nature of art, even as the art world remains governed by an elite nomadic network that claims to recognize genuine quality in its own ranks. How might artistic production navigate these paradoxes today, without either selling out to co-optation or languishing in impotence? The impact of cybernetic capitalism – with its feedback loops, neoliberal identity politics, and the financialization of creativity – looms large over this question, demanding a critical and nuanced response.

The Market Emperor's New Clothes

In the high echelons of the art market, success can become uncoupled from substance. A market-successful artist may rise to prominence through savvy branding, trend-chasing, or the patronage of powerful curators, even if the actual work is conceptually hollow. The situation recalls the fable of the emperor's new clothes: everyone flatters the emperor's exquisite (but nonexistent) outfit out of fear of seeming ignorant. Likewise, institutions and followers can be swept up by an artist's prestige or novelty, hesitating to call out the work as empty. In *Dimes is of the Essence*, I invoked just such a figure in "The Rat" – described as "a terminally online basement dweller who ideologically outsmarts sociality through indoctrinating a following into believing they are the emperor (but with new clothes)". This archetype satirically captures how a clever artist can manipulate social perception, using intellectual posturing or hype to convince an audience that they indeed wear magnificent artistic "new clothes." The fol-

lowers, like the emperor's subjects, are tricked into ascribing depth and meaning to what may be a vacuous gesture.

Such market-driven emperors often thrive on the inertia of institutions. Curators and collectors, being part of the same social ecosystem, may reinforce the illusion of significance. They are sometimes complicit in the charade, whether due to genuine belief or self-interest. In *Dimes is of the Essence*, I pointedly noted that a curator can be deemed a genius simply for performing the expected social rituals of the art world – “enact[ing] the social decorum necessary for the microsociality of the art world”. In other words, insiders praise one another for fluently speaking the code of the elite circle. When an artist emerges with the right pedigree, buzzwords, or aesthetic that flatters the prevailing tastes, institutions may embrace the work unquestioningly. The result is a feedback loop of validation divorced from artistic substance: the gallery system, critical press, and art fairs all echo each other's enthusiasm, and the work's market value soars. Yet this celebration can mask a reality of “boredom, impotence, and envy” beneath the glamour. I citing Gilles Châtelet's polemic, described how after the 1960s' revolutionary fervor collapsed, a “new breed of self-deluding ‘nomads’ and vogueish ‘gardeners of the creative’” eagerly embraced “the ‘revolutionary’ forces of the market's invisible hand”. These artists and their followers convinced themselves that the market's logic was a kind of liberation, only to end up mired in creative stagnation – a triumphant emptiness governed by fashion and envy rather than true innovation. The market “emperor”, in short, may reign in contemporary art, but often with no genuine artistic clothes on. What reigns in-

stead is a cultivated image or persona, a “fashionable...image within the attention economy” that generates desire and buzz even as “this image is ultimately finite and contrived”.

The Solipsistic Hermit and the Collapse of Insular Art

On the opposite end of the spectrum stands the solipsistic artist – the one who, disillusioned by the art world’s social games and market machinations, attempts to withdraw entirely into private creative autonomy. This artist rejects galleries, trends, and perhaps even audiences, cultivating an esoteric practice meant to be free from co-optation. At first glance, such hermetic dedication to one’s own vision appears noble – a refusal to dilute art’s purity. However, the paradox of solipsism in art is that complete withdrawal can render the work impotent. Without dialogue with a public or peers, the art risks communicating nothing beyond the artist’s own self-reflection. In extreme cases, it becomes inaccessible or irrelevant, a kind of private language. What’s more, the pretense of autonomy itself can be an illusion. In *Dimes of the Essence* I argued that many attempts to create art in a vacuum merely create a “pseudo-hermetic false enclosure,” one that in fact reifies the very elite values it claims to reject. The insider support may still be quietly present behind the scenes, propping up the “independent” artist’s ability to survive while shunning the market. Thus the work’s “purported non-instrumentality” (its claim to be free from use or exchange) becomes a subtle instrument of prestige. Rather than truly breaking from the system, the hermetic artist often relies on it by negation – their rebellion itself becomes a product that certain collectors, curators, or academic supporters

champion as the idea of artistic freedom. In this way, the artist's supposed freedom can devolve into "a Stoic libertarianism based on the mercenary's privileging of his opportunity over ideals". The work, instead of embodying higher ideals, collapses into a self-serving exercise: the artist takes the "opportunity" to be free (often enabled by personal privilege or patronage) without actually challenging the underlying power structures.

Far from being immune to corruption, solipsistic art can thus harbor its own form of hollowness. I explicitly identify "the recent trend of self-enclosure" – artists retreating into hermetic practice – and expose it as "an artistic self-enclosure in solipsistic artwork, once again founded not upon liberatory values, but [on] [elite] values which bolster the image of the artwork's solipsism". In other words, the lone visionary stance often bolsters the image of independence more than any real emancipation. The art becomes a kind of performance of refusal, easily romanticized by the very cultural elite the artist disdains. Ultimately, the solipsistic artist's work may collapse under its own insularity: by refusing to engage the social dimension of art at all, it forfeits the chance to effect change or to be understood as anything more than a private indulgence. What remains is an image or myth of the solitary genius—an image readily co-opted by the art world as another niche brand. The tragedy here is that genuine critical or expressive potential is lost in a closed loop. The hermetic artist, attempting to save art's meaning from the market, instead ends up with an art that has meaning only to themselves or a tiny coterie of initiates.

Art's Social Paradox: Nomadic Elites and the Illusion of Quality

Despite their opposing strategies, the market-friendly charlatan and the solipsistic hermit share a fundamental complaint: art's value today is too dependent on social relations. Both see the art world as a kind of corrupt social club – the charlatan exploits it cynically, and the hermit spurns it – implying that what counts as “good art” is simply what the right people say it is. There is truth in this observation. Art is indeed social; its meaning and value emerge from dialogue, context, and recognition. Within the art world exists an insider class often described (not without irony) as a nomadic elite. These are the curators, critics, artists, and collectors who circulate through biennials, art fairs, openings, and residencies across the globe – a tribe of insiders who, in effect, validate each other's tastes and judgments. My essay pointedly calls them a “vognish ‘self-deluded nomadic overclass’”, highlighting how they carry their values and norms with them from scene to scene. This elite functions as gatekeepers, and they recognize each other through shared criteria that outsiders might mistake for arbitrary fashion. In principle, those criteria could be called “genuine quality” – deep knowledge of art history, technique, and theory, or a honed sense for innovation. In practice, it can blur into simply recognizing the familiar markers of one's in-group (education, rhetoric, style). The social decorum of art insiders – from how one talks about art to what references one drops – is not just superficial etiquette but a mechanism for determining what work gets taken seriously.

Both the emperor-with-no-clothes artist and the hermit

artist chafe at this social reality. The former tries to game the system by mastering those insider codes or by shocking the system's sensibilities to garner attention, effectively saying: "If art value is a social construct, I will manipulate that construct to my advantage." The latter tries to escape the system, asserting that true value must exist outside this social game – yet in doing so often ends up defining themselves in opposition to the very social circle they left, which is still a form of relation. Meanwhile, the "global nomadic overclass elite" continues to operate, setting the zeitgeist of contemporary art. They travel light – switching allegiances to new movements when convenient – but consistently find ways to reassert their cultural authority by anointing what they perceive as quality. It is this elite consensus (however self-deluding it may sometimes be) that actually creates the social reality of art. If a truly meaningful work arises, it often takes hold because some group of connected people champions it, not simply because of its intrinsic merits in a vacuum. This does not mean that art is purely social convention – certainly works can move people deeply and display rigor or imagination that feels objective. However, it does mean that recognition of those qualities requires a community attuned to see them. The insider elite likes to believe it is such a community, scouting genuine quality amidst noise. To some extent, they do elevate work that has inventive form or critical insight (many insiders are sincerely motivated by love of art). But they also, inevitably, exclude perspectives outside their network and can ossify into yet another echo chamber of taste. The upshot is a bitter truth that both extremes acknowledge: to engage with art is to engage with a social

context. The challenge is whether one can do so without either blindly believing the hype or refusing all connection.

Cybernetic Capitalism: Identity and the Financialization of Creativity

Complicating this landscape are the forces of cybernetic capitalism and neoliberal culture, which have transformed how art is produced, circulated, and valued. Cybernetics – the science of systems, feedback, and control – has given us the digital networks and algorithms that now mediate much of artistic life. The art market and art discourse increasingly operate through online platforms, social media, and data-driven marketing. This creates feedback loops in which popularity can be quantified in clicks and likes, and trends can be rapidly amplified. As Châtelet observed, the veneration of “cybernetics and networks” often “merely impart[s] a futuristic sheen” to old ideologies. The rhetoric of connectivity and complexity becomes a “pseudoscientific alibi” for market logic – suggesting that if an artwork goes viral or fetches a high auction price, it must somehow be a natural, emergent indicator of quality or relevance. In reality, cybernetic systems can just as easily inflate the emperor’s new clothes or marginalize the hermit further. An artist skilled at social media manipulation might appear more significant than they are, while an introspective craftsperson who eschews Instagram might never be noticed at all. The attention economy tends to reward the loud and novel, collapsing artistic innovation into moments of trending visibility. Significant events or ideas can be flattened into what Gilles Châtelet calls “‘surprise parties,’ where significant events are flattened out and

equated with mere trends”. In such a climate, depth and sustained inquiry – the very stuff that genuine art requires – struggle against the demand for instant, surface-level impact.

Hand in hand with cybernetic networks are neoliberal identity structures. Neoliberalism treats individuals as entrepreneurial units, each responsible for curating and selling their identity. In contemporary art, this translates to artists often becoming brands of selfhood. One’s personal narrative (identity markers, biography, social affiliations) becomes intertwined with one’s artistic output. On one level, this has empowered diverse voices to assert their identity through art. On another level, it has invited co-optation: identity itself becomes a commodity. As I observed, “Identity politics is transformed into advertising sales and branding”, and even radical cultural forms can be appropriated as mere “simulation of the real”. A striking example given is the fate of underground techno music: originally a Black, Detroit-born innovation, techno’s aesthetic was adopted by a white European club scene and eventually by mainstream culture, stripping it of context until it became just another fashionable veneer. The novelty of the “new”, once a rallying cry for avant-garde progress, can thus be harnessed to serve the status quo – a new style is only the latest marketing hook. In our time, even oppositional or subcultural art gets swiftly folded into the market apparatus, often via identity-based packaging. The data-driven marketing strategies (the cybernetic aspect) intersect with identity by targeting niche demographics and tastes, turning even personal or political expression into “fodder for... feedbacked State control”, as seen when social media data about subcultures is repurposed for political ma-

nipulation. The financialization of creativity completes this picture: art is not only metaphorically about money but literally an asset class and a currency of influence. Financial capital flows into art as investment, while artists are forced to strategize grant applications, edition sales, and crowdfunding. The market alibis for any art project becomes, “but can it pay?” or “does it increase my cultural capital?” Under such pressures, co-optation of artistic impulses is an ever-present risk – every rebellion can be budgeted, every statement monetized. Indeed, my text drawing on Châtelet raises the idea of a “triple alliance” governing the contemporary economy: a tight feedback loop between politics, economics, and cybernetics. This alliance suggests that our entire social field (including art) is conditioned by interconnected forces of governance, profit, and informational control. The art world, despite its bohemian self-image, is deeply entangled in these systems. In practical terms, this means the emperor’s new clothes shine brighter (backed by algorithms and auction records), and the hermit’s tower grows taller (as isolation becomes not just a choice but sometimes the only refuge from ubiquitous surveillance and commodification).

Navigating the Paradox: Beyond Co-optation or Impotence

Given these daunting conditions, how can an artist or any cultural producer navigate between the Scylla of market co-optation and the Charybdis of solipsistic impotence? Both Dimes is of the Essence and Ultrablack of Music hint at possible avenues by critically examining the problem. One key is self-awareness: artists must remain cognizant of how easily

both rebellion and success can be appropriated. This means actively resisting the seductions of pure hype and pure hermitage. Artistic production might find a path forward by embracing a balance – engaging with society and its institutions, but on one’s own terms, and with a transparent acknowledgement of the compromises involved. In both essays, we find suggestions of hybrid strategies. For instance, instead of naively trying to stand completely outside the art world, one might act as a “double agent” within it. I raised the idea of enlightened insiders using the system’s tools (even something as arcane as pure mathematics or rigorous theory) to “enact a universalist program” from within elite structures. In plainer terms, this could mean artists leveraging their insider status or resources to critique and change the very framework that supports them. We see real-world examples in artists who use the gallery’s platform to deliver anti-capitalist messages or who funnel market earnings into community projects. The risk of co-optation never disappears, but it can be delayed or subverted by keeping the content of art unpredictable and critical even as its form enters conventional channels.

Another approach is suggested through the figure of the “Rooster” in Dimes is of the Essence – described as “the fool who escapes such a matrix of positions/camps”. The Rooster is an archetype of the artist who refuses to be pinned down as either sellout or recluse, insider or outsider. They might appear foolish because they do not play by the expected rules of either camp, yet in that very foolishness lies a form of freedom. Embracing the Rooster’s stance could mean cultivating playfulness, unpredictability, and genuine risk in art-making. It means not over-investing in one’s identity as either a mar-

ket darling or a pure outsider. This recalls the age-old idea of the holy fool in art and literature – the one who speaks truth to power under the guise of nonsense, or who sidesteps dogma through humor and creativity. By not taking the prescribed roles too seriously, an artist can slip through the cracks of the system, at least temporarily confounding both the market’s demand for commodification and the hermetic urge to remain completely sealed off.

Crucially, navigating the paradox also requires reasserting some notion of artistic integrity and purpose that neither succumbs to cynicism nor to naïveté. This might involve a return to the idea of art as a research or a practice of freedom that is collective as much as individual. Both essays yearn for a “true universalism” that could reconnect the private and public, the individual and society, outside of libertarian market logic. In practical terms, this could mean building alternative institutions (artist-run spaces, collectives, online commons) that operate by different values – not to create enclaves of purity, but to keep art tied to lived social causes and communities in a meaningful way. It could also involve interdisciplinary crossings: artists engaging with philosophy, science, or collectivism to infuse content that resists easy market digestion. This harkens back to a cybernetic idea in a positive sense – creating feedback loops between art and other domains of knowledge, so that art doesn’t become a self-referential cul-de-sac. The influence of figures like Gilles Châtelet or Jean-Luc Nancy on today’s zeitgeist suggests that philosophical rigor and reflection can be allies to art’s resistance, helping to demystify the false inevitabilities of cybernetic neoliberalism (like the notion that “there is no alterna-

tive” to the art market’s rules). By critically understanding the forces at play – the way “the ‘new’ can be statistically correlated to...a hive-mind” and weaponized – artists and theorists can devise new tactics of interruption or subversion that keep the flame of genuine creativity alive.

In the end, the spectrum between market success and solipsism is not a binary choice but a field of tension where thoughtful navigation is possible. The social nature of art is inescapable: rather than bemoan it, artists can work to reshape the social field around their work. Insiders can be challenged, expanded, or replaced by new networks; quality can be re-imagined not as a secret badge of the elite but as a collaborative discovery open to anyone willing to look deeply. Neither the naked emperor nor the silent hermit offers a sustainable model for the future of art. Instead, perhaps the way forward is more gardener than emperor or hermit – cultivating creative ideas slowly and communally, weeding out the influences of both mercenary trend and self-absorbed indulgence. This approach acknowledges that while money (and attention) may often be “of the essence” in our era, what truly gives art its essence is something that cannot be purchased or sequestered in solitude. It is the socially grounded yet independently striving work that stands the best chance of resisting co-optation while remaining vibrant. Contemporary art can aspire to be neither a puppet of the market nor a prisoner of solipsism, but something ultrablack (of music) in the best sense – absorbing all light and reflecting back a spectrum of possibilities beyond the simplistic dichotomy of success vs. integrity.

Categorical Cybernetics: A Framework for Computational Dialectics

The limits of my language mean the limits of
my world.

– Ludwig Wittgenstein, *Tractatus*
Logico-Philosophicus, 1922

At the intersection of category theory, cybernetics, and dialectical reasoning lies a profound framework for understanding computation and control. This paper examines how categorical structures—particularly adjoint functors and fixed points—illuminate the nature of feedback and control in both mathematical and philosophical contexts. Through an analysis of Lawvere’s fixed point theorem, Bayesian Open Games, and modern approaches to categorical cybernetics, we develop a unified perspective that bridges computation, control, and dialectical reasoning. We demonstrate the practical implications of this theoretical framework through a compiler pipeline that targets modern GPU architectures.

Introduction

The relationship between computation and control has been a central concern in computer science and cybernetics since their inception. While traditional approaches have often treated

these as separate domains, category theory reveals their deep interconnection through its emphasis on composition and universal properties. This mathematical framework provides not just a formal bridge between computational and control-theoretic perspectives, but also illuminates connections to dialectical reasoning in philosophy that have long been suspected but rarely formalized.

The power of categorical methods lies in their ability to reveal common patterns across seemingly disparate domains. In the realm of cybernetics and control, these patterns manifest as feedback loops and control structures. What makes category theory particularly suited to this analysis is its native handling of composition and its ability to express universal properties—precisely the features needed to understand complex control systems.

The Dialectics of Adjointness

Category theory's notion of adjoint functors provides perhaps the most precise mathematical formulation yet developed of Hegel's "unity of opposites." An adjunction between categories C and D consists of functors moving in opposite directions that nonetheless stand in perfect harmony through their relationship. This is not merely analogous to dialectical relationships in philosophy—it is a mathematical embodiment of the very principle.

To make this concrete, consider the fundamental example of the forgetful functor U from the cyclic group Z_{12} (representing clock arithmetic) to **Set**, and its left adjoint, the free functor F . The forgetful functor U simply takes a group element and "forgets" its group structure, leaving only the

underlying set. The free functor F goes in the opposite direction, taking a set and constructing the free group generated by that set.

This adjunction $F \dashv U$ captures a deep relationship: there is a natural bijection between group homomorphisms

$$\text{Hom}_{\mathbf{Grp}}(F(X), G)$$

and functions

$$\text{Hom}_{\mathbf{Set}}(X, U(G))$$

for any set X and group G .

In the context of clock arithmetic, this means that any function from a set into the underlying set of Z_{12} uniquely extends to a group homomorphism from the free group on that set to Z_{12} .

What makes this example particularly illuminating is how it demonstrates the complementary nature of adjoint functors. The forgetful functor U represents a kind of analysis—breaking down complex structures into simpler ones—while its left adjoint F represents synthesis—building up complex structures from simple ones. This mirrors precisely the dialectical movement between analysis and synthesis in philosophical thought.

Consider how this plays out in the realm of computation and control. Every computational process has its dual in the form of a control structure. When we compute forward, we simultaneously create the possibility of backward control. This duality is not accidental but fundamental to the nature of computation itself. The categorical perspective makes this explicit through the lens of adjoint functors.

This duality manifests concretely in the implementation of machine learning systems. Forward computation through a neural network is adjoint to backpropagation during training. This mathematical relationship, far from being merely convenient, reflects a deep truth about the nature of learning and control. The forward pass freely generates predictions, while the backward pass forgets details of the computation while preserving gradient information—a perfect example of adjoint functors in action.

The philosophical significance of adjunctions extends beyond their mathematical utility. They provide a formal framework for understanding how opposing concepts can be mutually defining and interdependent. This is precisely what Hegel aimed to capture with his dialectical method, but formalized with mathematical precision. When we understand a concept, we implicitly understand its opposite; when we construct something freely, we simultaneously define its constrained dual.

Bayesian Open Games and Computational Implementation

Recent work on Bayesian Open Games provides a concrete instantiation of these ideas. By treating games as morphisms in a suitable category, we gain a powerful new perspective on strategic interaction. The composition of these game morphisms corresponds to the combination of strategic situations—a form of dialectical synthesis made mathematically precise.

The implementation of Bayesian Open Games through a modern compiler pipeline demonstrates how categorical in-

sights can guide practical development. This pipeline, targeting high-performance GPU architectures through CUDA, consists of several key stages:

First, game specifications are expressed in a high-level domain-specific language that directly reflects the categorical structure of Open Games. This language captures both the strategic aspects of games and their probabilistic nature in the Bayesian setting.

Second, these specifications undergo a series of transformations through intermediate representations. Each transformation preserves the categorical structure while moving closer to executable code. The use of dependent optics provides a natural setting for automatic differentiation, enabling tractable computation of Bayesian Nash Equilibria.

Finally, the pipeline generates optimized CUDA code that can run efficiently on modern GPU architectures. This final stage involves careful consideration of memory layout and parallel execution patterns. The categorical framework guides these optimizations by making data dependencies explicit through morphism composition.

What makes this implementation particularly significant is how it demonstrates the practical value of categorical thinking. The compiler pipeline isn't merely implementing an algorithm—it's preserving mathematical structure through each transformation. This preservation of structure is what enables reliable parallel execution and optimization.

Self-Reference and Fixed Points

Lawvere's fixed point theorem stands as one of the most profound insights into the nature of self-reference. As Curt

Jaimungal elucidates: "Gödel's incompleteness theorem (all consistent formal systems aren't 'complete' provided it models arithmetic) and Turing's theorem (you can't always determine if a program halts) are what you've likely heard of already. There are various other no-go results in philosophy/math, like Cantor's theorem, Rice's, Lob's, Tarski's undefinability as well... What most people don't know about is that there's just one theorem that underlies all of these: Lawvere's fixed point theorem."

The theorem's power lies in its generality. As Jaimungal explains: "When a function maps elements from one set to another, Lawvere showed that if you have a 'nice' function (technically, a 'fixed point operator') that can map elements from a set of functions to another set, you'll always find a fixed point (an element that maps to itself). Importantly, we don't assume the existence of this operator. We derive it."

This result has profound implications for understanding self-reference. When you try to create a system that can fully describe itself, you're implicitly constructing a function that maps descriptions to descriptions. Lawvere's theorem shows that such a system must contain statements that talk about themselves—there's no way to avoid self-reference in sufficiently expressive systems.

The theorem's relevance to cybernetics becomes clear when we consider feedback loops in control systems. Every feedback loop involves some form of self-reference, and Lawvere's theorem helps us understand the inherent possibilities and limitations of such structures. The fixed points that inevitably arise in sufficiently expressive systems are precisely the stable states that control systems seek to achieve or avoid.

As Jaimungal notes: “Lawvere’s theorem consequently shows that any category rich enough to interpret ‘functions from objects to themselves’ will host a diagonal meltdown of some sort... When you say ‘Here’s a program that decides halting,’ you’re implicitly constructing an

$$X \rightarrow X^X$$

arrow, letting the system interrogate itself.” This insight connects directly to the limitations of computational systems and the nature of self-reference in artificial intelligence.

The philosophical implications are profound. The theorem suggests that certain forms of self-reference and recursion are not merely features of particular formal systems but are inherent in any sufficiently expressive framework for reasoning about itself. This has direct bearing on questions of consciousness, self-awareness, and the limits of formal reasoning systems.

Implementation Through Dependent Types

The practical implementation of these ideas relies heavily on dependent type theory. Dependent types allow us to express precise relationships between values and types, making it possible to encode complex categorical structures directly in code. This is particularly important for the compiler pipeline, where we need to maintain mathematical invariants through multiple transformation stages.

The use of dependent optics in our implementation is not merely a technical choice but a reflection of the deeper categorical structure. Optics provide a compositional ap-

proach to bidirectional computation—exactly what’s needed for implementing Bayesian Open Games. When compiled to GPU code, these compositional structures guide parallelization strategies.

The Emergence of Control: A Categorical Cybernetics Perspective

Modern categorical cybernetics synthesizes these threads into a coherent framework for understanding control, building on insights from “The Road to General Intelligence.” Control emerges from the interplay of opposing forces (captured by adjunctions), self-referential structures (illuminated by fixed point theorems), and compositional relationships (expressed through categorical structure).

The framework of Semantically Closed Learning (SCL) provides a concrete manifestation of these principles. In SCL, a system maintains semantic closure through the dynamic interaction between its model of the world and its model of itself. This closure is achieved through what the framework terms “endogenous situatedness”—the system’s ability to model its own causal capabilities as part of its environment.

At the operational level, this manifests as a fine-grained production system where rules fire concurrently and asynchronously. The system maintains a workspace containing learned relational knowledge and a representation of both world and system states. What makes this approach distinctively categorical is its treatment of rules as morphisms in a category, where composition corresponds to the construction of more complex behaviors from simpler ones.

The scheduling mechanism in SCL exemplifies the categorical approach to control. Rather than using a traditional centralized scheduler, the system employs what can be understood as a categorical lens structure, where the forward direction represents prediction and the backward direction represents control. This bidirectional structure is not merely an implementation detail but a fundamental expression of the adjoint relationship between observation and action.

The compiler pipeline demonstrates how this theoretical understanding translates into practical implementation. By preserving categorical structure through each compilation stage, we maintain the essential properties that make control possible. The resulting GPU code, while optimized for performance, still reflects the underlying mathematical relationships.

This perspective has profound implications for artificial intelligence. Rather than treating intelligence as purely computational, we should understand it as fundamentally cybernetic—concerned with control and feedback as much as calculation. The categorical framework makes explicit how these aspects interrelate and compose to create complex behaviors.

The notion of "granular inference" in SCL aligns perfectly with categorical cybernetics principles. Each inference step can be viewed as a morphism in a suitable category, with composition representing the construction of complex reasoning chains. The system's ability to maintain multiple concurrent lines of reasoning while remaining responsive to its environment is a direct consequence of this categorical structure.

Perhaps most importantly, the framework demonstrates how safety and control can coexist with open-ended learning.

By maintaining semantic closure through categorical structures, the system can adapt to new situations while preserving essential invariants about its behavior. This provides a formal basis for understanding how intelligent systems can be both flexible and reliable.

Performance and Scalability

The implementation on GPU architectures raises important questions about the relationship between theoretical elegance and practical performance. Our experience shows that categorical structure actually aids in parallelization—the clear specification of data dependencies through morphisms helps identify opportunities for concurrent execution.

The compiler pipeline achieves this by:

1. Analyzing the categorical structure of games to identify independent computations
2. Mapping these independent computations to parallel GPU threads
3. Managing memory transfers to minimize communication overhead
4. Preserving mathematical invariants throughout the optimization process

Conclusion

Category theory provides both a mathematical framework and a philosophical perspective on the relationship between

computation and control. The emergence of categorical cybernetics suggests that this relationship is not accidental but fundamental to the nature of both phenomena. Our implementation of Bayesian Open Games demonstrates how these theoretical insights can guide practical system development.

The practical implications extend beyond theoretical understanding. By recognizing the fundamental role of feedback and control in computation, we can design better systems that explicitly acknowledge and leverage these relationships. The future of artificial intelligence may lie not in ever-more-complex computations, but in better understanding and implementing the principles of control that emerge from categorical cybernetics.

Treatise on Intuitionistic Type Theory

by Johan Georg Granström

As collage technique replaced oil paint, the
cathode ray tube will replace the canvas.
Someday artists will work with capacitors,
resistors, and semiconductors as they work
today with brushes, violins and junk.

—Nam June Paik

Introduction

Johan Georg Granström's *Treatise on Intuitionistic Type Theory* represents a landmark contribution to our understanding of the philosophical foundations of Per Martin-Löf's intuitionistic type theory (ITT). The work is particularly noteworthy for its careful exposition of how ITT emerges as a sophisticated codification of Brouwerian intuitionism while simultaneously advancing a distinctly Kantian program in the philosophy of mathematics. This philosophical grounding, drawing heavily on both Kantian and Husserlian phenomenology, offers valuable insights into the nature of mathematical knowledge and computation.

The significance of this work cannot be overstated. At a time when type theory is gaining increasing prominence

in both mathematics and computer science, Granström provides a philosophical foundation that helps explain why type-theoretic approaches have proven so successful. By situating ITT within the broader philosophical tradition, particularly in relation to Kant's views on mathematical knowledge, the book illuminates both the historical development of constructive mathematics and its contemporary relevance.

The work comes at a crucial moment in the development of mathematical foundations. The increasing importance of computer-assisted proof and formal verification has led to renewed interest in constructive approaches to mathematics. Granström's analysis helps explain why type-theoretic foundations are particularly well-suited to meet these contemporary challenges. His careful exposition of the philosophical foundations of ITT provides essential context for understanding both its historical development and its future potential.

Moreover, the book represents a significant contribution to our understanding of the relationship between philosophy and mathematics. By showing how deep philosophical insights about the nature of mathematical knowledge inform the development of formal systems, Granström demonstrates the continuing relevance of philosophical reflection for mathematical practice. This is particularly valuable at a time when the relationship between philosophy and mathematics is often questioned.

Kantian Foundations

A central theme of Granström's work is the Kantian character of ITT. This manifests in several key ways that illuminate both the historical debates between Brouwer and Hilbert over

Kant's philosophy of mathematics and the contemporary relevance of Kantian ideas in type theory:

3.2.1 Constructive Nature

The constructive nature of ITT aligns closely with Kant's view that mathematical knowledge requires the construction of concepts in pure intuition. Granström carefully shows how Martin-Löf's approach to types as "defined by laying down what counts as a cause of the proposition" (p. 28) echoes Kant's insistence on the constructive nature of mathematical knowledge. This connection helps explain why ITT provides a natural formal setting for constructive mathematics.

The book's treatment of construction in mathematics is particularly valuable for its careful analysis of how ITT realizes Kant's insights about the nature of mathematical knowledge. Granström shows how the type-theoretic approach to mathematical existence through construction provides a rigorous formal treatment of Kant's ideas about the role of construction in mathematical knowledge. This treatment helps explain why ITT succeeds where other approaches to constructive mathematics have sometimes fallen short.

Of particular significance is Granström's analysis of how ITT's treatment of mathematical existence aligns with Kant's view that mathematical objects must be constructible in pure intuition. This stands in stark contrast to set-theoretic approaches that posit the existence of mathematical objects independently of any possible construction. Granström shows how ITT's constructive approach provides a formal framework that better captures the actual character of mathematical knowledge.

Furthermore, the book demonstrates how ITT's treatment of mathematical truth through evidence captures Kant's insight that mathematical knowledge requires both intuition and concepts. The type-theoretic approach to mathematical truth through canonical proof terms provides a formal treatment of how mathematical knowledge combines intuitive and conceptual elements in precisely the way Kant described.

3.2.2 Forms of Judgment

The book's treatment of the various forms of judgment in ITT reveals deep parallels with Kant's table of judgments. Particularly noteworthy is how Granström connects Martin-Löf's four forms of categorical judgment with Kantian ideas about the nature of mathematical knowledge.

Granström's analysis of judgment is especially valuable for showing how ITT provides a formal treatment of mathematical knowledge that preserves the distinctive character of mathematical judgment that Kant identified. The book shows how the type-theoretic approach to mathematical truth through evidence aligns with Kant's insights about the synthetic a priori nature of mathematical knowledge.

Notably, there is Granström's analysis of how ITT's treatment of categorical judgment relates to Kant's distinction between analytic and synthetic judgments. The book shows how the type-theoretic approach to mathematical truth captures the synthetic character of mathematical knowledge while maintaining its a priori status. This helps explain why ITT provides such a natural setting for constructive mathematics.

Moreover, Granström demonstrates how ITT's treatment of hypothetical judgment aligns with Kant's understanding

of the role of construction in mathematical reasoning. The type-theoretic approach to dependency captures how mathematical knowledge builds on prior constructions in precisely the way Kant described. This formal treatment of dependency provides a sophisticated framework for understanding how mathematical knowledge is structured.

The book also shows how ITT's treatment of equality judgments relates to Kant's views about mathematical identity. Granström's analysis reveals how the type-theoretic approach to definitional equality captures important aspects of Kant's understanding of mathematical sameness.

3.2.3 Pure Intuition and Type Formation

One of the most interesting aspects of Granström's treatment is his analysis of how ITT's rules for type formation relate to Kant's notion of pure intuition. The book shows how the type-theoretic approach provides a rigorous formal treatment of how mathematical concepts are constructed in pure intuition.

The connection to Kant's views about pure intuition is particularly valuable for understanding why ITT succeeds in capturing the distinctive character of mathematical knowledge. Granström shows how the type-theoretic treatment of mathematical concepts through rules of formation and introduction captures important aspects of Kant's account of mathematical concept formation.

The book's analysis of how type formation rules relate to the construction of concepts in pure intuition is especially illuminating. Granström demonstrates how ITT's approach to type formation provides a formal treatment of how math-

ematical concepts are constructed that aligns with Kant's understanding of mathematical knowledge.

Furthermore, Granström shows how ITT's treatment of canonical forms relates to Kant's views about the role of schema in mathematical knowledge. The book reveals how the type-theoretic approach to canonical terms captures important aspects of how mathematical concepts relate to intuition.

What stands out most is Granström's analysis of how ITT's universe hierarchy relates to Kant's views about the systematic nature of mathematical knowledge. The book shows how the type-theoretic treatment of universes captures important aspects of how mathematical knowledge is structured.

Phenomenological Insights

One of the most valuable aspects of Granström's treatment is his careful exposition of how ITT incorporates insights from Husserlian phenomenology. This connection to phenomenology proves crucial for understanding both the philosophical foundations of type theory and its practical success in formalizing mathematical knowledge.

3.3.1 Meaning Explanations

The book's treatment of Martin-Löf's meaning explanations shows how they draw on Husserl's ideas about meaning and evidence. Granström demonstrates how these explanations provide a philosophically sophisticated account of mathematical knowledge that avoids both Platonism and formalism

while maintaining mathematical rigor.

Particularly valuable is Granström's analysis of how meaning explanations relate to Husserl's account of categorical intuition. The book shows how ITT provides a formal treatment of mathematical concepts that preserves their intuitive content while achieving mathematical precision.

Granström's exposition reveals how Martin-Löf's approach to meaning explanations captures Husserl's insight that meaning involves both intention and fulfillment. The type-theoretic treatment of canonical forms provides a formal framework for understanding how mathematical meanings are constituted through acts of understanding.

The book also demonstrates how ITT's treatment of computation relates to phenomenological ideas about meaning constitution. Granström shows how the type-theoretic approach to computation captures important aspects of how mathematical meanings are understood and verified.

3.3.2 Types as Intentions

Granström's analysis of how types in ITT can be understood as intentions in the phenomenological sense provides valuable insight into the philosophical significance of dependent types.

The phenomenological interpretation of types is especially valuable for understanding why dependent types prove so useful in practice. Granström shows how the type-theoretic treatment of mathematical concepts through dependent types captures important aspects of how we actually understand and use mathematical concepts.

It is particularly important to note that Granström's analysis of how dependent types relate to Husserl's account of

meaning dependence. The book shows how ITT's treatment of dependency captures crucial aspects of how mathematical meanings are structured.

Furthermore, Granström demonstrates how ITT's treatment of canonical forms relates to phenomenological ideas about meaning fulfillment. The book reveals how the type-theoretic approach to canonical terms captures important aspects of how mathematical meanings are verified.

The book also shows how ITT's treatment of computation relates to phenomenological accounts of evidence. Granström reveals how the type-theoretic approach to computation captures important aspects of how mathematical meanings are understood through acts of verification.

3.3.3 Evidence and Truth

The book's treatment of the relationship between evidence and truth in ITT reveals important connections to phenomenological ideas about knowledge and evidence.

One of the most important considerations is Granström's analysis of how ITT handles the relationship between truth and evidence. Drawing on Husserl's analysis of evidence as the "fulfillment of meaning intentions," Granström shows how ITT's treatment of mathematical truth through the notion of canonical proof captures the phenomenological insight that mathematical truth is inherently tied to evidence. This stands in stark contrast to classical approaches that treat truth as potentially transcending all possible evidence.

The book's treatment of this topic is especially valuable for showing how ITT provides a formal framework that preserves the intimate connection between truth and evidence

that phenomenology identifies. Granström demonstrates how Martin-Löf's type theory succeeds in formalizing the insight that mathematical truth cannot be separated from the possibility of evidence.

The Brouwer-Hilbert Debate Revisited

A particularly valuable contribution of the book is its treatment of how ITT relates to the historical debate between Brouwer and Hilbert over the foundations of mathematics. Granström demonstrates how ITT provides a sophisticated synthesis that preserves key insights from both thinkers while moving beyond their apparent opposition.

3.4.1 Law of Excluded Middle

Granström's careful analysis of the intuitionistic interpretation of the law of excluded middle shows how ITT provides a sophisticated formal framework for Brouwer's insights about the nature of mathematical truth. The discussion of proof by contradiction and the various forms of disjunction is particularly illuminating.

The book shows how ITT provides a formal treatment of constructive mathematics that preserves Brouwer's insights while achieving the kind of mathematical precision that Hilbert sought. A crucial aspect of this is Granström's analysis of how ITT handles classical reasoning principles. He demonstrates how the type-theoretic approach allows for a more nuanced understanding of classical principles like the law of excluded middle by distinguishing between different forms of disjunction and different notions of negation.

Furthermore, Granström shows how ITT's treatment of the law of excluded middle relates to deeper questions about the nature of mathematical truth. He reveals how the type-theoretic approach captures important aspects of Brouwer's insights about the relationship between truth and provability while maintaining rigorous formal standards. This helps explain why ITT succeeds in providing a foundation for mathematics that is both constructive and precise.

The book demonstrates how ITT's treatment of classical reasoning principles relates to questions about the nature of mathematical existence. Granström shows how the type-theoretic approach allows for a sophisticated understanding of existence claims that preserves constructive content while acknowledging the practical value of classical reasoning methods.

3.4.2 Formal vs. Contentful Mathematics

The book shows how ITT transcends the opposition between Hilbert's formalism and Brouwer's intuitionism by providing a formal system that nevertheless preserves mathematical content. This achievement is shown to rest on Martin-Löf's philosophical insights about the nature of mathematical knowledge.

Particularly valuable is Granström's analysis of how ITT achieves formality while preserving mathematical content. The book shows how the type-theoretic approach provides a rigorous formal treatment of mathematics that nevertheless maintains the intuitive content that Brouwer emphasized.

The book demonstrates how ITT's treatment of formal rules relates to questions about mathematical meaning. Granström

shows how the type-theoretic approach captures important aspects of both formal precision and mathematical content through its sophisticated treatment of meaning explanations.

Of special significance is Granström's analysis of how ITT handles the relationship between syntax and semantics. The book reveals how the type-theoretic approach achieves a sophisticated integration of formal and contentful aspects of mathematics through its treatment of canonical forms and computation.

3.4.3 The Role of Proof

Granström's treatment of the role of proof in ITT provides important insights into how the type-theoretic approach relates to both Brouwer's and Hilbert's views about mathematical proof. The book shows how ITT provides a formal treatment of proof that preserves important intuitionistic insights while achieving the kind of precision that Hilbert sought.

A key point to highlight is Granström's analysis of how ITT handles the relationship between proof and truth. The book shows how the type-theoretic approach captures important aspects of both the evidential and formal nature of mathematical proof through its sophisticated treatment of canonical proof terms.

Furthermore, Granström demonstrates how ITT's treatment of proof construction relates to deeper questions about mathematical knowledge. He shows how the type-theoretic approach captures important aspects of both the creative and formal aspects of mathematical proof through its treatment of computation and normalization.

The book also reveals how ITT's treatment of proof ob-

jects relates to questions about mathematical meaning. Granström shows how the type-theoretic approach captures important aspects of both the epistemic and semantic roles of proof through its sophisticated treatment of the Curry-Howard correspondence.

Contemporary Relevance

The contemporary significance of Granström's analysis extends well beyond historical and philosophical concerns, reaching into the heart of current mathematical practice and computer science. His work illuminates why type-theoretic approaches have proven so effective in addressing contemporary challenges in formal verification, programming language design, and mathematical foundations.

3.5.1 Computer Science

The book makes a compelling case for the contemporary relevance of these philosophical ideas by showing how they illuminate practical issues in computer science and programming language design. The connection between types and propositions (the Curry-Howard correspondence) is shown to have deep philosophical significance that extends far beyond its technical formulation.

Granström's analysis reveals how ITT's philosophical foundations inform modern programming language design. The book demonstrates how type-theoretic approaches to programming language semantics capture important insights about the nature of computation and mathematical knowledge. This helps explain why strongly typed programming languages

have proven so effective in practice.

Central to this issue is Granström's treatment of dependent types in programming. The book shows how the philosophical insights underlying ITT's treatment of dependency illuminate why dependent types provide such powerful tools for program specification and verification. This analysis helps explain the growing adoption of dependent types in programming language design.

Furthermore, Granström reveals how ITT's philosophical foundations inform the development of proof assistants and interactive theorem provers. The book shows how the type-theoretic approach to mathematical knowledge provides natural foundations for computer-assisted mathematics. This helps explain why type-theoretic proof assistants have proven so effective in practice.

3.5.2 Foundations of Mathematics

Granström convincingly argues that ITT provides a more satisfactory foundation for mathematics than either set theory or category theory, precisely because of its philosophical sophistication. The book shows how ITT's treatment of mathematical existence and truth aligns better with mathematical practice than competing approaches.

The analysis of ITT as a foundation for mathematics is especially valuable for showing how philosophical insights about the nature of mathematical knowledge can inform mathematical practice. The book demonstrates how the type-theoretic approach provides a foundation that better captures the actual character of mathematical knowledge and reasoning.

Of particular significance is Granström's analysis of how ITT handles abstract mathematical concepts. The book shows how the type-theoretic approach provides a sophisticated treatment of mathematical abstraction that preserves constructive content while supporting abstract reasoning.

The book also reveals how ITT's treatment of mathematical structures relates to questions about mathematical ontology. Granström shows how the type-theoretic approach provides a nuanced understanding of mathematical existence that avoids both Platonism and nominalism.

Moreover, Granström demonstrates how ITT's treatment of mathematical proof relates to questions about mathematical knowledge.

3.5.3 Future Directions

Granström's treatise points toward several important directions for future research in both the philosophical and technical development of type theory. One significant area for further investigation is the relationship between intuitionistic type theory and categorical logic. While the book touches on categorical interpretations of type theory, a more systematic exploration of how ITT relates to categorical foundations would be valuable. This investigation could help clarify the relative advantages of type-theoretic and categorical approaches to constructive mathematics while potentially suggesting ways they must be unified.

The connection between ITT and Kant's specific views about arithmetic and geometry represents another promising direction for future research. While Granström establishes important parallels between ITT and Kantian philosophy of

mathematics in general, a more detailed analysis of how ITT relates to Kant's treatment of specific mathematical domains would be valuable. This could help clarify both the historical significance of ITT and its relevance to contemporary debates about the foundations of mathematics.

A third important direction concerns the implications of ITT for mathematical practice. While the book establishes the theoretical significance of type-theoretic approaches, more work is needed to understand how these ideas can improve actual mathematical practice. This includes investigating how type-theoretic methods can be integrated into existing mathematical workflows, how they can support computer-assisted proof development, and how they might influence mathematical pedagogy.

The relationship between ITT and homotopy type theory represents another crucial area for future investigation. While homotopy type theory has emerged as an important development of Martin-Löf's ideas, more work is needed to understand how the philosophical foundations Granström describes relate to this new approach. This investigation could help clarify both the philosophical significance of univalent foundations and its relationship to traditional intuitionistic type theory.

The role of computation in mathematical knowledge deserves further attention. Granström's treatment of computation is insightful, but more work is needed to understand how computational perspectives inform our understanding of mathematical knowledge.

Finally, the relationship between ITT and classical mathematics requires further investigation. While the book estab-

lishes the philosophical advantages of constructive approaches, more work is needed to understand how classical and constructive mathematics can productively coexist. This includes investigating how classical results can be reformulated constructively and how constructive methods might inform classical practice.

These directions for future research suggest the ongoing vitality of the philosophical program Granström describes. They also indicate how philosophical reflection on the foundations of mathematics can continue to inform both mathematical practice and our understanding of mathematical knowledge.

Critical Assessment

While Granström's treatment is generally excellent, there are some areas where further development would be valuable:

3.6.1 Technical Details

While Granström's treatment is generally excellent, the technical exposition could benefit from further development in several areas. The book sometimes moves quickly through complex technical material that deserves more detailed treatment. This is particularly evident in the treatment of dependent types, where more examples would help readers understand how the philosophical insights inform the technical development.

The relationship between the philosophical foundations and the technical details could be more fully explored. While the book makes a compelling case for how phenomenological

insights inform the structure of ITT, more concrete examples of how these insights shape specific technical features would strengthen the argument. For instance, the connection between meaning explanations and the rules for type formation could be illustrated with more detailed examples.

Additionally, the technical treatment of key concepts like canonicity and computation could be expanded. While the philosophical motivation for these concepts is well-explained, more detailed technical exposition would help readers understand how these ideas are realized in practice.

The book's treatment of advanced topics like universe hierarchies and inductive definitions would also benefit from more technical detail. While the philosophical foundations for these concepts are well-explained, more concrete examples would help readers understand how these ideas work out in the field.

3.6.2 Historical Context

The historical context for ITT's development could be more fully explored. This would help readers understand how ITT relates to earlier constructive approaches and why it represents such a significant advance.

The relationship between ITT and earlier constructive systems like recursive arithmetic and Heyting arithmetic could be developed more fully. This historical context would also help explain why ITT succeeds where earlier approaches encountered difficulties.

Furthermore, the book could more fully explore the historical development of phenomenological approaches to mathematics. While Husserl's influence on Martin-Löf is well-

documented, the broader tradition of phenomenological reflection on mathematics deserves more attention, such as Jean Cavailles.

The historical relationship between type theory and logic could also be explored more fully. While the book discusses the Curry-Howard correspondence, the broader history of type-theoretic approaches to logic deserves more attention.

3.6.3 Practical Applications

The practical implications of ITT's philosophical foundations could be developed more fully. While the book makes a compelling case for the theoretical significance of these ideas, more concrete examples of how they inform mathematical practice and computer science would strengthen the argument.

The relationship between ITT and program verification deserves particular attention. While the book discusses the Curry-Howard correspondence, more detailed examples of how ITT's approach to mathematical knowledge informs practical verification efforts would be valuable. This would help readers understand how philosophical insights about the nature of mathematical knowledge can improve software reliability.

The relationship between ITT and interactive theorem proving could be developed more fully. While the book touches on this connection, more detailed examples of how ITT's philosophical insights inform the design and use of proof assistants would be valuable.

Furthermore, the book could more fully explore ITT's implications for programming language design. While the connection between types and propositions is well-explained,

more concrete examples of how these ideas inform language design would strengthen the argument.

The implications for mathematical education also deserve more attention. While the book focuses on theoretical foundations, ITT's approach to mathematical knowledge has important implications for how mathematics is taught and learned.

Conclusion

Granström's treatise represents a major contribution to our understanding of the philosophical foundations of type theory. By showing how ITT emerges from deep philosophical insights about the nature of mathematical knowledge, the book helps explain why type theory has proven so successful as a foundation for both mathematics and computer science.

The work is essential reading for anyone interested in the philosophy of mathematics, type theory, or the foundations of computer science. Its careful analysis of how ITT relates to both historical debates about the foundations of mathematics and contemporary issues in computer science and mathematical practice makes it a valuable resource for a wide range of readers.

Perhaps most importantly, the book shows how philosophical reflection on the nature of mathematical knowledge can inform and improve mathematical practice. In an era when formal methods are becoming increasingly important in both mathematics and computer science, Granström's philosophical analysis helps explain why type-theoretic approaches have proven so successful and points toward how they might be developed further.

The Limits of Formalization: Mathematics, AI, and Human Creativity

A Systems Esthetic will become the dominant approach to a maze of socio-technical conditions rooted only in the present.

— Jack Burnham

This essay examines the historical development of technopositivism from the Manhattan Project through contemporary AI research, analyzing the dialectic between formal mathematical systems and human creative intuition. Central to this analysis is the tension between attempts to formalize mathematics through automated systems and the irreducible aspects of human mathematical and artistic creativity. Through examination of key developments from von Neumann to Grothendieck, and from type theory to AI, we explore how this tension shapes our understanding of consciousness, creativity, and the limits of artificial intelligence.

Introduction

The trajectory of 20th and 21st century mathematics reveals a fundamental tension between formalization and intuition, between mechanical computation and human creativity. This dialectic emerged dramatically with the Manhattan Project, where figures like Oppenheimer and von Neumann embodied the fusion of abstract mathematics with technological power. The subsequent development of computer science, cryptography, and artificial intelligence has only intensified this tension. Modern attempts to formalize mathematics through type theory and automated theorem proving raise profound questions about the nature of mathematical understanding and the limits of artificial intelligence.

This tension manifests most clearly in two divergent paths: the drive toward complete formalization and automation of mathematics, exemplified by developments in homotopy type theory and AI, and the persistence of irreducible human intuition in mathematical and artistic creativity. The story of Alexander Grothendieck, who revolutionized mathematics before withdrawing into mystical contemplation, serves as an emblematic case of this dialectic.

The Technical Foundations of Modern Power

The Manhattan Project marked a pivotal moment in the relationship between mathematics and technological power. The development of the atomic bomb, coupled with von Neumann's work on computer architecture, established a paradigm of technopositivism that continues to shape our world. This paradigm extended beyond military applications into the foun-

dations of modern cryptography, where pure mathematical results like Fermat’s Last Theorem found unexpected applications in elliptical curve cryptography and secure communication protocols.

The state’s appropriation of mathematical knowledge for its ideological apparatus is evident in the development of encryption technologies. What began as pure mathematical inquiry into number theory and algebraic geometry has become instrumental in both securing and surveilling digital communications. This transformation exemplifies how abstract mathematical structures become tools of power and control.

Paths Forward: Formalization and Its Alternatives

For contemporary mathematicians and creators, two main paths present themselves. The first involves embracing new paradigms of cybernetics and applied category theory. This approach, pursued by researchers like David Spivak and Jules Hedges, seeks to apply categorical methods to dynamical systems and game theory. While ostensibly apolitical, this work finds funding from both military sources (via institutions like the Topos Institute) and civilian governance projects (through EU initiatives).

The second path involves a deeper engagement with mathematical foundations through homotopy type theory (HoTT). This approach attempts to provide a new foundation for mathematics, superseding both Russell’s failed logicism and the independence issues of set theory. Per Martin-Löf’s dependent type theory, understood as a codification of Kantian philosophy, suggests that mathematical truth is inseparable from

human construction and verification.

The Limits of Artificial Intelligence

The limitations of AI in mathematical and artistic creativity become apparent when we consider the nature of human understanding. While AI can manipulate formal systems through type theory and automated theorem proving, it fundamentally lacks access to the multiple interpretative frameworks available to human mathematicians. The four different ways of approaching mathematical problems - through proof theory, category theory, type theory, and homotopy theory - suggest a richness of understanding that transcends purely formal manipulation.

This limitation becomes particularly evident in attempts at artistic creation. AI's inability to create a "total work of art" stems from its confinement to formal syntactic and semantic structures. The human capacity for topological intuition and creative synthesis, whether in mathematics or art, suggests an irreducible aspect of consciousness that resists complete formalization.

The Black Box of Understanding

The fundamental question of whether mathematics is discovered or invented relates to deeper questions about the nature of reality and human understanding. Following Thorsten Altenkirch's interpretation of Leibniz's law, we might view mathematical objects as "black boxes" defined by their behavior rather than their internal structure. This perspective suggests that the traditional analytic/synthetic distinction

becomes less relevant than the functional adequation between mathematical structures and reality.

Just as financial markets never fully capture the noumenal reality of underlying assets but only their phenomenal behavior, our mathematical and computational models may never fully capture the nature of consciousness or creativity. This limitation points toward a form of semantic anti-realism (where all philosophical problems can be reduced to a debate between Platonist and Intuitionist philosophy of math): questions about the ultimate nature of reality give way to pragmatic considerations of mathematical and artistic practice.

Conclusion

The tension between formalization and human creativity remains unresolved and perhaps unresolvable. While AI and automated systems can manipulate formal mathematical structures with increasing sophistication, they remain fundamentally limited by their inability to engage with mathematics in the multiple, intuitive ways characteristic of human understanding. The path forward may lie not in choosing between formalization and intuition but in maintaining their productive tension.

Grothendieck's trajectory - from revolutionary mathematician to mystical hermit - suggests that the deepest mathematical insights may require both rigorous formalism and intuitive understanding that transcends formal systems. As we continue to develop AI and automated mathematical tools, we must remain mindful of the irreducible aspects of human creativity and understanding that resist complete formaliza-

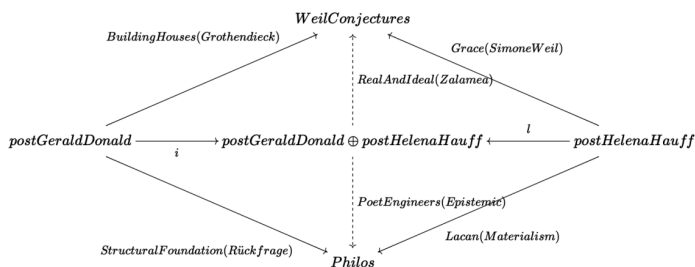
tion.

Toward a New Cybernetic System: The Dance Between Abstract and Concrete

By the late twentieth century, our time, a
mythic time, we are all chimeras, theorized
and fabricated hybrids of machine and
organism; in short, we are cyborgs.

— Donna J. Haraway

In the intersection between theoretical abstraction and lived reality, we find a call for a new cybernetic system—one that bridges the gap between the houses we build in thought and the spaces we actually inhabit. This system emerges from two distinct yet intertwined paths: the abstract-theological realm of building theoretical frameworks, and the concrete domain of love and philosophical questioning.



The Architecture of Thought

At one pole, we have the construction of theoretical houses, exemplified by Grothendieck's mathematical structuralism. These are the abstract frameworks we build to understand reality, the mathematical scaffolding that supports our comprehension of the world. Yet these structures are perpetually outstripped by grace—that ineffable element which, as Simone Weil reminds us, “fills empty spaces, but can only enter where there is a void to receive it.” This tension between structure and void creates a productive dialectic.

The metaphor of “building houses,” drawn from Grothendieck's reflection, serves as more than mere analogy. As he notes in *Récoltes et Semailles*, mathematicians often inherit a “large and beautiful fully-furnished house,” complete with its tools and conventions. But the true builder-pioneer must venture beyond these comfortable confines, must risk the solitude of open air to construct new dwellings for thought.

The Material Ground

At the other pole lies the actual reality of desire and materiality, approached through two methodological vectors: Husserl's “questioning back” (*Rückfrage*) and Lacanian materialism. The former provides a phenomenological method for interrogating the foundations of our experience, while the latter reveals how desire structures our relationship to reality through language and lack.

Rückfrage, as a methodological principle, suggests that we must constantly return to the origins of sense, to the *Lebenswelt* (lifeworld) that grounds all scientific and theo-

retical construction. This “questioning back” isn’t merely historical or empirical but transcendental—it seeks the conditions that make experience possible.

The Lacanian perspective complements this by revealing how desire structures our relationship to reality. Our desires are themselves as separated from our actual bodily needs as the phallus is separated from any biological penis. This gap, this separation, is precisely what allows for the construction of new theoretical frameworks.

Two Subjects, One System

5.3.1 Gerald Donald and the Afrofuturist Vision

Gerald Donald’s work with Drexciya represents more than mere musical innovation. By creating a complex mythology of underwater dwelling descendants of drowned slaves, he demonstrates how theoretical frameworks can process historical trauma through abstraction. The “Drexciyan” mythology serves as what we might call a “dimensional jumphole” between African roots and contemporary America.

This mythological construction isn’t escapism but rather a sophisticated theoretical framework that allows for the reimagining of historical trauma through technological means. Donald’s later work as Arpanet, referencing early computer networks, further develops this theme of technological mediation of historical experience.

5.3.2 Helena Hauff and Technological Ambivalence

Helena Hauff embodies a different relationship to technology and abstraction—one that sees in electronic music both utopian possibility and apocalyptic potential. Her approach to electronic music reflects what Zalamea calls the tension between the real and ideal. Her raw, hardware-based approach to electronic music production represents a direct engagement with the materiality of technology, while still serving abstract, theoretical ends.

The Direct Sum and Its Implications

5.4.1 Mathematical Formalization

The use of direct sum notation (\oplus) isn't merely metaphorical. As defined:

Let U, W be subspaces of V . Then V is said to be the direct sum of U and W , and we write $V = U \oplus W$, if $V = U + W$ and $U \cap W = \{0\}$.

This mathematical formalization suggests that the combination of these two approaches creates a new space that preserves their individual characteristics while generating something novel.

5.4.2 Toward the Real and Ideal

The first morphism moves toward what Zalamea identifies as the tension between real and ideal. This isn't a simple opposition but rather a productive dialectic. Scientific truth corresponds to the correct adequation between facts and the

representation of those facts. The direct sum of our two positions generates a new way of approaching this adequation.

5.4.3 Engineering Poetic Reality

The second morphism points toward what we might call “poet-engineers.” This figure combines technical expertise with poetic sensibility, suggesting a new way of engaging with reality that is both constructive and imaginative. Engineering qua Plato’s idea of craftsmanship is already the ultimate form of poesis.

The Role of Technology

Technology serves a crucial mediating function in this cybernetic system. As Donald notes, “Technical devices allow the rank and file to express their ideas and to move forward in the socio-economic continuum more effectively.” This isn’t merely about tools but about the creation of new possibilities for thought and action.

5.5.1 The Digital Interface

The role of digital technology in this system isn’t simply instrumental. Rather, it creates what we might call “dimensional jumpholes”—spaces where different realities can interface and interact. This is evident in both Donald’s mythological constructions and Hauff’s raw engagement with electronic hardware.

Grace and the Void

The system is perpetually haunted by what Simone Weil identifies as grace—that which “fills empty spaces, but can only enter where there is a void to receive it.” This suggests that our theoretical constructions must maintain certain voids, certain spaces of indeterminacy, to remain vital and generative.

5.6.1 The Role of Desire

Lacanian theory helps us understand how desire functions within this system. The *objet petit a* serves as an organizing principle for desire, creating what we might call coordinates for our own desire. This structuring of desire is crucial for both theoretical construction and practical engagement.

The Cybernetic Resolution

What emerges is a cybernetic system that doesn’t merely oscillate between abstraction and concrete reality, but actively synthesizes them. It suggests that the houses we build in theory must be inhabited by grace, while our questioning of reality must be structured by desire. This creates a feedback loop where:

- Abstract frameworks are constantly “questioned back” to their phenomenological origins
- Material reality is continually restructured through theoretical intervention

- Grace and desire serve as the operators that move between these domains
- Technology functions as both medium and message, both tool and terrain

Practical Implications

This theoretical framework has practical implications for:

5.8.1 Artistic Practice

The integration of technical expertise with poetic sensibility suggests new approaches to artistic creation, particularly in electronic music and digital arts.

5.8.2 Theoretical Construction

The emphasis on “questioning back” while maintaining rigorous formal structures suggests new ways of building theoretical frameworks.

Conclusion

This new cybernetic system suggests that the path forward lies neither in pure abstraction nor in pure materiality, but in their dynamic interplay. It calls for a practice that is simultaneously theoretical and concrete, mathematical and poetic, structural and graceful. The direct sum of our subjective positions doesn’t resolve their tensions but makes them productive, generating new ways of building houses for thought while ensuring they remain habitable by love.

Like the electronic music that serves as our model, this system oscillates between structure and freedom, pattern and noise, the ideal and the real. It suggests that our theoretical frameworks are not mere abstractions but living spaces that must be continually rebuilt and reinhabited, while our concrete reality is not mere matter but a field of potential waiting to be structured by thought and grace.

In the end, this system points toward a new way of being in the world—one that recognizes the necessity of both rigorous theoretical construction and open spaces for grace, both technological mediation and direct engagement, both historical memory and future projection. It suggests that the path forward lies not in choosing between these alternatives but in finding ways to hold them together in productive tension.

Toy Philosophy Universes: On Philosophical Modeling Through Contemporary Art

Press Release for forthcoming exhibition at
Centralbanken, Summer 2026

The body is our general medium for having a
world.

— Maurice Merleau-Ponty

Exhibition

At a time when both art and philosophy grapple with questions of modeling reality and constructing knowledge, Reza Negarestani's concept of "toy philosophy universes" offers a compelling framework for understanding how experimental practices might generate new forms of thought. This exhibition brings together seven artists whose work engages with the construction of philosophical models and systems, exploring what Negarestani calls "the implicit know-hows and know-thats behind our attempts at forming a theory, model or conception of this or that aspect of the world."



Artist Practices

6.2.1 Valerie Keane

Keane's hanging sculptures operate as complex systematic models that merge industrial fabrication with baroque sensibilities. Her work, informed by architectural theorists like Frederick Kiesler and Victor Horta, creates what Negarestani

might term “toy universes” through their intricate manipulation of commercially available materials. Using laser-cut Perspex and water jet-cut metal, Keane constructs resolute and finite compositions that, in their tension between delicacy and violence, demonstrate how technological processes can be redirected toward philosophical modeling. Her practice particularly resonates with Petersen’s notion of contradiction as generative force, as her sculptures simultaneously embrace and resist technological progress, creating what critic Robert McKenzie calls “functionless objects that are elaborately hand crafted.”

6.2.2 Asha Sheshadri

Sheshadri’s video installations and essayistic recordings examine how institutional structures shape knowledge production, particularly through the lens of postcolonial theory. Her work commingles memory construction, questions of citation and translation, and personal and political histories to create what Negarestani might call “toy universes” that allow us to observe and manipulate these systems from outside. By layering her own voice with found documents, literature, manifestos, and cinema, Sheshadri creates environments that challenge traditional hierarchies of knowledge production while exploring how colonial histories continue to shape our understanding of reality.

6.2.3 Tim Pierson

Pierson’s paintings investigate logical structures through what he terms “composition in the expanded field.” Drawing from his theoretical framework that links painting, mathematics,

and music through the concept of composition, his work engages with what he describes as “the atomic unit by which one constructs any type of distinction.” His paintings particularly resonate with Uwe Petersen’s concept of “contraction free logic,” as they explore how “the category-theoretic narrative” can move beyond traditional pictorial terms into what he calls “the wilds of intrasubjective space.”

6.2.4 Giangiacomo Rossetti

Rossetti’s paintings explore the tension between world-building and world-representation through a unique approach to art historical citation. By embedding his own image within compositions that reference Renaissance masters and Pre-Raphaelites, Rossetti creates what Negarestani might call a “toy universe” that both honors and subverts traditional representational frameworks. His “infiltrating gesture” reanimates historical images while depleting them of their original significance, creating what his gallerist describes as “a subjective vision of art’s genealogy that is committed to the dissemination of painting’s nonlinear evolution.”

6.2.5 Bedros Yeretizian

Yeretizian’s installations investigate what Uwe Petersen calls “freeing the conflicts of reason with itself” through experimental material processes. His use of unconventional materials like instant coffee, piss, and vitamin C to develop photographs creates spaces where contradictions become generative rather than destructive. This approach aligns with Negarestani’s conception of toy philosophy universes as frameworks where “formalism and systematicity come hand in hand.”

6.2.6 Max Guy

Guy's work, centered recently on *The Wizard of Oz*, examines how fantasy and reality can coexist within philosophical frameworks. His exploration of "slippage between worlds" and "boundaries so porous one could be blown through them by a strong enough wind" resonates with Negarestani's discussion of world-building versus world-representation. Guy's practice demonstrates how even "the simplest acts of world-making" can generate new philosophical insights.

6.2.7 Lauren Burns-Coady

Burns-Coady's practice explores mimesis and embodiment through a critical engagement with Ana Mendieta's work, while simultaneously visualizing abstract logical systems. Her pieces make concrete the theoretical frameworks discussed by both Negarestani and Petersen, investigating how visual art can function as a form of philosophical modeling itself.

Toy Philosophy Universes

Through this engagement with philosophical modeling, the exhibition explores how contemporary art can contribute to our understanding of knowledge construction and theoretical thinking. The artists' diverse approaches to material and conceptual experimentation create their own "toy philosophy universes" that challenge viewers to reconsider the relationship between logic, representation, and artistic creation.

Publisher in Residence

The exhibition is accompanied by theoretical support from Bauer Verlag, whose publishing practice establishes vital connections between visual art and critical theory. Their involvement emphasizes the exhibition's commitment to bridging artistic practice and philosophical inquiry.

Mathematics as Metaphysical and Constructive

Press Release for exhibition *Artist's Artist*, 3
July - 29 September 2024, Rue Américaine 13

Tim Pierson, Lauren Burns-Coady, Connor
Camburn, Emma Sims, Bauer Verlag, Alyssa
van Denburg, Max Guy, Connor Tomaka,
Matt Voor, Peter Wolfgang, Keith Farquhar,
P.E.O.P.L.E., with a sound installation by
Sean McCann; curated by Eric Schmid

Weil, Grothendieck and Mac Lane

André Weil viewed mathematics as deeply intertwined with metaphysics. In his essay "From Metaphysics to Mathematics," he illustrates how mathematical ideas often arise from vague, metaphysical analogies and reflections that guide researchers toward new theories. For instance, Weil discusses how analogies between different areas, such as number theory and algebraic functions, have led to significant breakthroughs. These metaphysical underpinnings provide a fertile

ground for mathematical creativity, eventually transforming into rigorous mathematical structures. Alexander Grothendieck's work, particularly in "Récoltes et Semailles," resonates with Weil's ideas by emphasizing the organic and generative aspects of mathematical creation. Grothendieck sees mathematical work as akin to cultivating a garden, where ideas grow and develop in a nurturing environment. He describes the process of mathematical discovery as a deeply personal and creative journey, involving both solitary reflection and collaborative effort. Grothendieck's concept of creating mathematical "houses" aligns with his broader philosophical view that mathematics provides structures within which new ideas can flourish. His work in category theory and algebraic geometry exemplifies this approach, where he developed vast, interconnected frameworks that have become foundational in modern mathematics. Grothendieck's analogy of constructing houses for others to live in highlights the mathematician's role in creating abstract frameworks that others can inhabit and explore. This metaphor emphasizes the constructive nature of mathematics, where researchers build theoretical structures that form the basis for further exploration and application by the mathematical community. In "Mathematics: Form and Function," Saunders Mac Lane explores the nature of mathematical problems and their role in mathematical practice. Mac Lane emphasizes that mathematical problems are not merely puzzles to be solved but are central to the development of mathematical theory. He discusses how problems guide research by highlighting gaps in existing knowledge and suggesting new directions for inquiry. Mac Lane identifies several key philosophical questions about

mathematics, such as the nature of mathematical truth, the existence of mathematical objects, and how we gain knowledge of these truths and objects. He also explores the reasons behind the "unreasonable effectiveness" of mathematics in explaining the physical world, suggesting that mathematical structures are so well-suited to describe reality because they are developed through a continuous process of abstraction and generalization from real-world problems. Moreover, Mac Lane argues that the development of mathematics is driven by the desire to solve specific, often famous, mathematical problems. These problems stimulate new techniques, ideas, and even entire branches of mathematics. For example, the attempts to solve Fermat's Last Theorem led to significant advancements in algebraic number theory.

Grothendieck Universes and Category/Topos Theory

Grothendieck Universes are a set-theoretic concept used to handle large collections of mathematical objects in a coherent way. A Grothendieck Universe is a set that contains all the usual sets one might work with in a particular context, including sets of sets, and is closed under the operations of set theory. This concept allows mathematicians to work with large categories and other structures without running into paradoxes associated with naive set theory. Category theory, and particularly topos theory, leverages Grothendieck Universes to manage large and complex structures. In category theory, a Grothendieck Universe provides a framework in which one can define categories whose objects and morphisms are themselves sets within the universe, ensuring that operations within the category remain well-defined and con-

sistent. This is crucial for dealing with large categories that would otherwise be too unwieldy to handle within standard set theory. The use of Grothendieck Universes in category theory stipulates a richer ontology than Zermelo-Fraenkel set theory with the Axiom of Choice (ZFC). While ZFC provides a robust foundation for mathematics, Grothendieck Universes enable the handling of large-scale structures in a way that is more natural and flexible for certain areas of research, particularly in algebraic geometry and homotopy theory. The Tarski-Grothendieck set theory, which incorporates the notion of Grothendieck Universes, extends the expressive power of ZFC by allowing for the existence of large sets that are not typically accommodated within the standard ZFC framework

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