

Reframing Authorship and Ethics in AI-driven and Immersive Architectural Environments: A Transdisciplinary Review

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Abstract

This article presents a comprehensive transdisciplinary review of the ways in which artificial intelligence (AI) and immersive technologies are transforming foundational concepts of authorship, ethics, and creativity within contemporary architecture and spatial design. The traditional notion of the architect as a singular, authoritative creator increasingly is challenged by computational processes that introduce generative, autonomous, and distributed forms of design agency. Through a synthesis of architectural theory, AI ethics, media studies, and posthuman philosophy, the review interrogates the shifting locus of authorship in design environments mediated by intelligent systems and extended reality (XR) platforms.

At the core of this inquiry is an ontological reframing of authorship, informed by scholars such as Rosi Braidotti, Tony Fry, Humberto Maturana, and Anne-Marie Willis. These frameworks position the architect not as an originator of form, but as a participant in a relational field of human and non-human agents, including algorithms, data, environments, and users. Adopting an ontological design lens, under which design practices and their tools co-produce forms of life and ways of world-making, the article argues that AI/XR systems do not merely assist representation but actively configure professional authorship, agency, and ethics. This framing links practical workflows to normative guidance for disclosure, responsibility, and education. The review explores how generative design, neural networks, and parametric modeling redefine design intention and originality, situating authorship as a curatorial and computationally entangled process. In parallel, immersive media such as virtual and augmented reality introduce new forms of user co-authorship and spatial manipulation, prompting ethical questions about consent, agency, presence, and the authenticity of digital space.

The article maps emerging discourses around design accountability, legal attribution, algorithmic bias, and data governance, proposing an expanded ethical vocabulary for posthuman design practices. Through a critical examination of scholarly literature, experimental studios, and case-based applications, the review identifies epistemological and practical challenges in reconciling human-centered traditions with distributed technological agency.

Ultimately, this article argues for a redefinition of authorship as a dynamic, ethically situated, and ontologically pluralistic concept in architecture. It advocates for the development of integrative frameworks that embed ethical foresight and philosophical reflexivity into AI-augmented and immersive design methodologies. By repositioning the architect as a negotiator within hybrid systems of creativity and control, the article contributes a forward-looking perspective to architectural theory, technological practice, and planning discourse.

Keywords

Ontological design; Posthuman authorship; Immersive architecture; AI ethics; XR environments; Generative design

1. Introduction

Artificial intelligence and immersive technologies are redefining contemporary architecture, dissolving the Renaissance ideal of the singular architect genius by introducing collaborative algorithmic design and extended reality (XR) environments where users co-create space; this shift distributes creative agency between humans and machines and demands a fresh understanding of architectural authorship in the twenty-first century (El Moussaoui, 2025a; El Moussaoui, 2025b).

This article adopts ontological design as its primary interpretive frame. Ontological design posits that design activity and its artefacts recursively configure human practices, subjectivities, and lifeworlds; it is therefore concerned with design's world-making effects rather than with artefacts alone. In Anne-Marie Willis's formulation, ontological designing characterizes the two-way shaping between humans and their designed environments (Willis, 2006); Tony Fry extends this into a re-directive practice attentive to the futures design brings into being (Fry, 1999). Reading contemporary AI/XR through this lens, computational pipelines are not neutral helpers: they structure perception (what is seen as salient), distribute agency (what is easy or hard to do), and stabilize norms (what counts as legitimate authorship or evidence). Consequently, questions of attribution, bias, privacy, and immersive manipulation are ontological before they are merely technical or legal. This framing animates the article's subsequent mapping of hybrid authorship (Section 3), ethical risk domains and mitigations (Section 4), and implications for professional governance and education (Section 5).

Two intersecting shifts define the problem space. First, AI-driven design now extends from technical optimization to creative generation as models produce floor plans and façades with little guidance, making authorship ambiguous when outcomes blend human intent and machine proposals (El Moussaoui, 2025b). Second, immersive media (virtual reality/VR, augmented reality/AR, and mixed reality/MR) erases boundaries between designer occupant and space; users alter virtual elements in real-time and become co-designers. Architecture unfolds within a responsive digital layer that continuously links physical and virtual realms, raising new questions about whether authorship lies with the architect who built the system, the algorithms that update it, or the occupants who shape it through interaction.

AI-driven design and immersive environments erode the idea of single authorship in architecture; when an architect selects an AI-generated option or an XR overlay reshapes a building, authorship may belong to the architect, the software developers, or the user. These questions affect professional practice, intellectual property, liability, and design ethics: firms using generative tools struggle to assign ownership of machine produced concepts (AIA Contract Documents, 2024), while speculative urbanism disperses vision and intent across multidisciplinary teams and algorithms. Ethical scrutiny intensifies as architects confront algorithmic bias, transparency, accountability (Sunil, 2024), and the need to protect consent, privacy, and psychological well-being in virtual environments (Raja & Al Baghli, 2025).

The convergence of AI and immersive media disrupts entrenched ideas of authorship agency and responsibility in architecture, demanding theoretical clarity and ethical guidance; this review therefore melds architectural theory and history, posthumanist philosophy, computational design research, and emerging policy frameworks to reframe authorship for today's networked design reality, first tracing its evolution from humanist

to posthumanist perspectives, then analysing how AI fosters computational creativity and co-authorship, examining the ethical implications of immersive experiences, and finally proposing legal, ethical, and professional reforms to distribute and govern authorship in AI-augmented practice, ultimately advancing a distributed collaborative and ethically-grounded model of authorship for a posthuman era of design.

2. Theoretical Frameworks and Foundational Concepts

To understand the current upheaval in architectural authorship, it is instructive to trace how the concept of the “architect-author” evolved and how it is now being reinterpreted through posthuman and ontological frameworks. In Western architecture, the role of the architect as author has its roots in the Renaissance humanist tradition. Renaissance theorists such as Leon Battista Alberti positioned the architect’s authorship in the lineaments, a precise outline “conceived in the mind,” distinct from the act of building (Alberti, 1991), while Giorgio Vasari framed *disegno* as the “parent of our three arts,” grounding authorship in intellectual design rather than manual craft (Vasari, 1907). The classical ideal of the Vitruvian Man, famously illustrated by Leonardo da Vinci, placed the human designer at the center of the universe of creation (Softaoglu, 2022). This human-centric paradigm gave rise to what we recognize as authorship in architecture: buildings were attributed to individual designers whose creative intentions and personal style were paramount. Throughout the centuries of early modern architecture, this view persisted, reaching an apogee in the “starchitect” culture of the 20th and early 21st centuries, where signature designers like Le Corbusier, Zaha Hadid, or Frank Gehry were celebrated as singular authors of iconic works. Yet, even at its height, the notion of solitary authorship was complicated by the reality of collaborative practice (large teams, engineers, clients) and the influence of context and tradition. Those complications often were downplayed in favor of the mythos of individual genius.

Posthumanist and ontological perspectives decenter the human author and foreground the entanglement of human and nonhuman agencies in design; posthumanism articulated by Rosi Braidotti (Braidotti, 2013) moves beyond the Renaissance ideal of the autonomous subject by proposing a relational ontology where the human is one actor among life, technology, and matter (Softaoglu, 2022). Applied to architecture, Braidotti’s theory (Braidotti, 2017) shows that ideas emerge from interactions among people, algorithms, materials, and environmental forces rather than a single mind. Authorship becomes distributed as architects, computational systems, users, and even buildings through performance feedback, co-create form and meaning. Braidotti clarifies that posthuman does not eliminate humans but reframes creativity by recognising AI systems and ecological processes as subjects, challenging the primacy of the *Anthropos* (Softaoglu, 2022). In this networked view the architect acts as coordinator and interpreter instead of sole creative source (El Moussaoui, 2025b).

Ontological design, elaborated by Tony Fry (Fry, 1999) and Anne-Marie Willis, extends the posthuman turn by framing a reciprocal loop in which people shape the built world and that world subsequently shapes human behaviour, perception, and identity (Willis, 2006); design is thus subject decentred, since “things as well as people design” (Willis, 2006). Fry captures this reciprocity with the aphorism that everyone is both a designer and designed, making authorship multidirectional rather than unilateral. The architect therefore operates within an ongoing feedback cycle: concepts are conditioned by existing technologies and cultural narratives that arose from prior designs, and completed buildings influence society and future creative work beyond the architect’s control. Authorship consequently is ontological, concerning the becoming of both people and artifacts through their continuous interactions (Willis, 2006).

Maturana's concept of autopoiesis shows that living systems self-produce and sustain their form through internal regulation and structural coupling with the environment (Maturana & Varela, 1980); when applied to design, a project or built environment becomes an autopoietic system that evolves through interactions among people, tools, materials, and information, dissolving the idea of a sole author because every element acts as co-author, and as Rolf Hughes notes, once such a system is launched the original designer blends into a hybrid human-machine collective, a semi-living presence rather than an exclusive creator (Theodoropoulou, 2007).

Digital historian Mario Carpo argues that the "second digital turn" shifts architectural practice from drawing forms to writing the rules that generate them (Carpo, 2017). Building on *The Alphabet and the Algorithm* (Carpo, 2011), he shows how algorithms act as a new architectural notation, collapsing representation and production and enabling mass-customised variation at negligible cost. In the current era of cloud computing and AI diffusion models, these scripts become probabilistic design engines whose outputs the architect curates rather than authoring singularly (Carpo, 2017).

This echoes Maturana's insight that all observers (or designers) are participants in bringing forth the world they observe/design. In practice, an architectural project can be seen as a consensual domain arising from the coupling of the designers' intentions, computational generative processes, and the environment's responses. Authorship in this light becomes emergent and collective. The architect is no longer an autonomous originator, but what Arief (2014?) calls a metadesigner or design curator – someone who configures the conditions under which socio-technical systems can generate form. This redistribution of agency resonates with post-humanist critiques that ask the designer's ego to step aside in favour of a more diffused authorship. Yet, collaboration still demands guidance. As Carl Steinitz (2020) reminds us, "almost everything we do to change the landscape by design requires collaboration ... with architects at the smaller scale, urban designers at the middle scale, geographers at the larger scale, and with engineers at all scales, and layers and bankers and government officials, yet with no one losing his/her professional identity." This design-curator role therefore hinges on orchestrating multi-scalar teams while safeguarding each discipline's expertise.

By reframing architectural authorship through posthuman and ontological lenses, we arrive at a concept of authorship as entangled and multiple. The humanist image of the solitary architect-author is replaced by a posthuman image of the architect as part of a transhuman network – a constellation including AI algorithms (as creative agents), a diverse human stakeholder team (from future occupants to technical, policy, and business partners), and the material world itself (as an agent with affordances and feedback). Such a reframing has profound ethical implications, which will be explored later: it implies that creativity and provisional responsibility are shared across the network, yet the licensed lead architect must still sign and bear ultimate accountability for the final design. Before turning to those ethical dimensions, we will examine in detail how AI-based computational creativity is unfolding in architectural practice and how it exemplifies these theoretical shifts. The next section delves into the practical realm of neural networks, generative design platforms, and algorithmic agency, analyzing how they transform the creative process and the locus of authorship in architecture.

3. Technological Developments and Creative Agency in Design Practice

Digital tools have long supported architects but the latest AI-driven systems go beyond CAD and BIM efficiency to deliver computational creativity; earlier software documented and optimised designs yet did not invent novel ideas (Vergunova & Vergunov, 2022). Machine learning models evolutionary algorithms and

procedural generators now create plans, volumes, and façades with a degree of autonomy turning software into a creative collaborator and reframing authorship. The landscape spans parametric environments such as Grasshopper for Rhino, node based algorithmic design platforms generative planning services like Autodesk Forma that guide early-stage site and massing studies, and visualisation add-ins like Veras that translate geometry into images. Architects therefore negotiate a balance between algorithmic automation and human oversight to preserve creative intent and ethical accountability.

AI now enables architects to generate many design options with little effort; early parametric tools such as Grasshopper ceded some authorship to scripted rules yet still relied on human parameters, while generative models like generative adversarial networks (GANs) or diffusion networks trained on vast precedent datasets can invent façades or spatial layouts that were never programmed. For example, given sufficient training data, a GAN can imagine façade compositions or spatial layouts in a chosen style or for a target performance, but each output still demands human vetting for structure, code compliance, and constructability, as generative models often miss technical constraints. The AI tool Midjourney or OpenAI's DALL·E, though originally geared towards images, have been used by designers to create concept art for buildings and cities based on text prompts. In such cases, the "authorship" of the visual concept immediately is in question: who deserves credit – the prompt author, the human illustrators whose images trained the model, or the team that scripted and maintains the algorithm itself (El Moussaoui, 2025a)? In this workflow the architect increasingly acts as curator and interpreter, choosing and refining machine proposals rather than relying solely on personal imagination (El Moussaoui, 2025b). This collaboration confirms a distributed authorship in which architect dataset designers and AI collectively shape the final outcome.

Industry practice is beginning to reflect this new reality. Autodesk's Forma (formerly known through development as Spacemaker) uses AI algorithms to quickly generate and evaluate urban design schemes, suggesting building placements, heights, and orientations on a given site based on performance criteria (sunlight, wind, density, etc.). An architect using Forma might set high-level constraints and let the software generate plan or massing options. Authorship nominally is shared, yet, much like auto-calibration in engineering, real responsibility remains with the professional: unless the architect understands why the algorithm produced each variant, the exercise devolves into opaque curve-fitting that cannot be defensibly explained to a client. Generative BIM plug-ins similarly auto lay out floor plans, optimise circulation, and size structural elements, so architects guide rather than draw and creative agency dissolves between computational emergence and human intention (Arief, 2014?). The architect's expertise lies in steering the process, tuning parameters, vetting results, adding context, much as in the Silicon Architect prototype, where two competing machine learning networks generate variants that still need architect-led curation for a credible outcome (Kemkomnerd & Tirapas, 2025). This shift raises practical questions: how much influence does the designer retain, and at what point might the design be considered machine-authored? Experimental studies in evolutionary design have suggested that architects often must adopt a meta-design stance, focusing on designing the rules of a system, to "regain control" over processes that otherwise could lead to unexpected results (Arief, 2014?). In other words, the architect authors the algorithm that authors the design, a layered form of authorship.

Veras by EvolveLAB demonstrates AI's influence on visual style and materiality; the plug-in uses image trained generative models to produce realistic renderings and alternative aesthetics for a 3D massing, and after an architect creates basic geometry in Rhino or Revit the software proposes façade textures, lighting scenarios, and context imagery that overwrite visual attributes based on learned patterns (Day, 2024). This

blurs boundaries between human intent and machine suggestion because if the architect adopts an unexpected façade proposed by Veras authorship is shared with the system's pattern recognition engine. Practitioners treat the tool as an extension of human agency, a sophisticated brush rather than a replacement for creativity, and following American Institute of Architects guidance they stress that AI may supply options while architects must provide critical judgment, contextual understanding, and ultimate responsibility for quality and humanity (Sunil, 2024).

AI's growing creative role raises urgent questions of intellectual property and liability: current law generally awards ownership to the human user because US copyright requires a human author, so architects may claim works produced with AI support, yet as systems gain autonomy firms face claims that the software creator or algorithm owner also merits credit since the tool shapes the result (Masood, 2025; (AIA Contract Documents, 2024). Others hold that only the human guiding objectives is the real author because AI creativity derives from human supplied data and goals (AIA Contract Documents, 2024). The AIA acknowledges this ownership dilemma and anticipates new contracts or legal doctrines as traditional authorship definitions strain to cover AI collaboration (AIA Contract Documents, 2024). Responsibility further complicates matters: if an AI-generated structure fails or violates codes the human architect remains accountable, so despite shared credit liability stays human, motivating cautious adoption and rigorous validation of AI outputs.

AI designs can inherit bias and shallow context because models learn from limited precedents, for example Western modernist datasets, leading to narrow aesthetics and neglect of culturally diverse solutions (Sunil, 2024); while algorithms excel at optimizing daylight or structural efficiency, they often miss site culture, history, and lived experience, and heavy reliance risks homogenising architecture into forms favoured by data patterns, stifling individual innovation (Sunil, 2024). Architects therefore must inject narrative, meaning, and heterogeneity, treating AI as an idea stimulant rather than final judge; much as photography pushed painters to clarify their unique contribution, AI forces architects to define the human creative value they add, since conceptual depth and contextual storytelling remain human strengths (El Moussaoui, 2025a). AI broadens the solution space and speeds exploration, but selecting designs that resonate with cultural memory and place still depends on human empathy and responsibility for meaning.

In summary, AI's rise has shifted the architect's role from sole creator to lead collaborator, working with intelligent systems and a multidisciplinary human team to shape design outcomes; the process resembles a sympoiesis, a collective making in which human and machine intelligences iterate so authorship becomes hybrid. Practitioners must grasp algorithmic logic, steer co-creativity, and guard the ethical and qualitative aspects that algorithms miss. The forthcoming discussion addresses these ethical stakes, particularly where immersive interactive environments heighten issues of user agency, consent, and the nature of reality that contemporary architecture must resolve.

4. Ethical Dimensions of Immersive Architectural Environments

Immersive technologies now complement AI by reshaping how architecture is designed, represented, and experienced. Virtual, augmented, and mixed reality, collectively termed extended reality (XR), are transforming practice, client engagement, and even the definition of built space by presenting architecture as dynamic, responsive worlds in which users play an active role, raising ethical questions about agency, presence, consent, and the blending of real and virtual domains. As design enters this mediated realm, ethical standards remain in flux and must evolve to address the participatory phenomenological shift.

In VR simulations or AR augmented spaces users may toggle information layers in a plaza or rearrange furniture in a virtual building, gaining partial design authorship and prompting architects to create adaptive frameworks rather than fixed sequences while deciding how much user agency to allow; too little agency reduces immersive value whereas too much risks incoherence, so authorial control becomes shared in a manner akin to a branching narrative where the designer prepares multiple paths and the user chooses among them. The ethical practice must empower participants yet guide them to avoid chaos or harm, embedding codes of conduct that curb malicious actions in shared environments (Ethics in Virtual Reality, 2022; PresenceSecure, 2025).

A key feature of VR is the feeling of presence – the psychological state of feeling “inside” a virtual environment. High-fidelity immersive architecture can induce powerful emotional and cognitive responses. A virtual building can evoke awe or fear similar to a real one if the illusion is convincing. This leads to ethical concerns about emotional manipulation and psychological comfort (Yee & Bailenson, 2007; Banakou et al., 2016; Madary & Metzinger, 2016; Slater & Sanchez-Vives, 2016; Regulation (EU) 2024/1689, 2024). Architects have long considered how real spaces affect mood and behavior; now they must consider virtual spaces with equal seriousness. An immersive environment can, for example, simulate dangerous heights, enclosed darkness, or other stimuli that might cause real distress or even trauma. Users may need to be screened for susceptibility (like acrophobia in a tall building VR simulation) or given clear options to opt out of intense experiences, touching on the issue of informed consent. Recent evaluation work on multi-sensory VR placemaking confirms this double edge. Testing a prototype that combined visual, acoustic, and kinesthetic cues, Globa et al. (2022) found that participants’ sense of presence and place-attachment scores rose sharply compared with a vision-only version, yet a minority also reported brief sensory overload and disorientation, signaling the need for careful calibration of stimulus intensity and exposure time. The ethics of realism in VR also include truthfulness and deception. When AR is used in real architecture, for example, overlaying a proposed building onto a current streetscape for a public consultation, the realism can be so strong that people might forget it is a simulation. Ethically, the creators should make clear what is virtual so as not to deceive stakeholders. In a broader sense, as one paper on the ethics of VR notes, when virtual experiences become indistinguishable from real, we must develop “a code of ethical conduct” to address potential harms and misuse (Madary & Metzinger, 2016). Empirical research further links extended or poorly calibrated exposure to cybersickness, disorientation, and post-experience fatigue (Sharples et al., 2008; Rebenitsch & Owen, 2016); higher presence itself can intensify these symptoms when visual and vestibular cues conflict (Weech et al., 2019). Clinical studies note that immersive recreations also may re-activate trauma or heighten anxiety if not carefully moderated (Rizzo & Koenig, 2017). This spans issues from ensuring no undue harm (simulations not inducing lasting fear, discomfort, or moral violation) to respecting the dignity and autonomy of users within virtual settings. For architects, this might mean designing virtual environments that are not only compelling but also safe, not just physically (avoiding simulator sickness through good design) but psychologically and socially safe.

The notion of consent in immersive architectural environments operates on several levels. There is experiential consent whereby users should have control over entering an immersive experience and be able to exit or pause if needed. For example, an AR installation in a public space might inadvertently involve passersby who have not consented (imagine AR layers that some see and others do not, which could affect those not using the system). Designers thus have to consider ambient consent: making sure that immersive augmentations in public do not infringe on the rights or comfort of non-participants. Another crucial aspect is data consent and privacy. Immersive systems often track user movements, gaze, biometrics (like heart rate if

VR equipment includes it) – all to create responsive environments or analyze behavior. Such data can be deeply personal, revealing how people react to spaces. Ethical design dictates that users are informed about what data are collected and how the data are used (Slater et al., 2020; Commis Tech LLC, 2024). For instance, if a virtual architecture application monitors where users look the most in a virtual building (to inform design improvements), users should consent to this analysis. There also is the risk of surveillance in augmented spaces: if AR devices record video of environments, there are implications for bystanders' privacy. Consent becomes a community issue, not just individual, in public AR deployments. The convergence of architecture and digital tech thus forces architects to grapple with privacy policies and informed-consent mechanisms, much like software engineers do. Longitudinal work on sensor-laden “adaptive architecture” shows that even seemingly benign environmental data, light levels, body-heat maps, or Wi-Fi traces, can be recombined into sensitive personal profiles, requiring explicit data-minimisation, purpose-limitation, and opt-out protocols (Schnädelbach et al., 2019).

Some scholars argue for designing consent experiences into VR/AR, e.g., brief interactive tutorials that explicitly ask users to agree to certain conditions before fully engaging (SecurePrivacy, 2025). For architectural presentations, this could be as simple as an opening screen that outlines content warnings and data usage. As AR and MR overlay digital content onto physical architecture, we enter an era of hybrid environments where the distinction between the real and the virtual can be fluid. Ethically, architects and planners face the challenge of maintaining a sense of authenticity and public trust. Consider a historical site enhanced with AR reconstructions of lost structures: it can enrich understanding, but if done without clear delineation, could it blur the history and mislead about what is original? There is an ethical duty to truth in representation. Similarly, urban environments might become palimpsests of virtual advertisements, art, or information when viewed through AR glasses. Who controls this virtual “layer” of the city? Could it be curated in a way that is inclusive and respectful of the physical context, or will it become a free-for-all dominated by corporate interests? Some have proposed that cities might need digital zoning laws: regulations for AR content in public space to prevent visual clutter or harassment (for instance, to stop someone from projecting offensive virtual graffiti on someone's house). Legal scholars already are outlining how conventional land-use zoning could be extended into the “digital air-space” that augmented-reality (AR) overlays occupy, allocating virtual “air-rights,” restricting offensive or misleading content, and balancing the speech interests of AR developers with the nuisance concerns of property owners (Conroy, 2017; Judge & Brown, 2018). Early policy experiments are underway: after crowds of Pokémon Go players damaged a lakeside park, Milwaukee County, Wisconsin briefly required AR game publishers to obtain a permit before placing geolocated content in any public park, an example of the very kind of digital zoning that cities may need to prevent virtual graffiti, harassment, or congestion (Behm, 2016). Emerging rules create a kind of regulatory architecture for immersive spaces, similar to physical signage laws, where accessibility is vital so AR or VR enhancements do not privilege those who can afford or use the devices while others experience an “unenhanced” reality; universal design principles therefore must extend to digital augmentations, and agency lies not only with users but also with system providers whose tools, such as AR navigation apps, must respect privacy and building security (for instance by avoiding routes through private offices).

Emerging frameworks in immersive architectural practice are adapting Institutional Review Board (IRB) protocols to virtual-reality projects to secure consent and manage risk (Raja & Al Baghli, 2025). They also introduce care-ethics approaches and co-created codes of conduct that let developers and users jointly set norms for virtual spaces. Architects must engage in these efforts so that long-standing professional values

(public welfare, health, and safety) inform new tech ethics that now address data integrity and psychological security as well as material issues. Regulatory bodies may soon craft guidelines for virtual building overlays or AR public art, while professional organisations such as the American Institute of Architects and the Royal Institute of British Architects (RIBA) discuss best practices to avoid misleading VR presentations and to ensure on-site AR safety. Advocates are calling for an Ethical Design Manifesto for XR. The manifesto would pledge transparency (clearly labelling virtual elements), user autonomy (opt-out controls), inclusivity (designing for diverse abilities), and sustainability (reusing digital assets and limiting hardware waste). For example, an AR tour of ruins could label reconstructions; a toggle could lower simulation intensity; 360-video could serve motion-sensitive users; and cross-project model reuse could cut energy demand.

Recent case studies go further, showing how immersive tools can broaden participation across gender and ability lines. A multi-stakeholder project at KTH Royal Institute of Technology used VR walk-throughs to let wheelchair users and neurodivergent participants annotate a proposed campus extension; design revisions led to wider corridor widths, lower interface heights, and gender-inclusive resting rooms (Malakhatka et al., 2025). Likewise, biomedical researchers have used short VR vignettes that simulate low-vision or limited-mobility scenarios; post-experience surveys showed significant gains in empathy scores among able-bodied participants and prompted concrete retrofit suggestions for public-transport hubs (Pinto-Coelho et al., 2023). Such examples underline that “inclusive VR” is not just about comfort settings but about empowering under-represented voices to shape space.

Table 1 offers a snapshot of the main extended-reality (XR) modalities used in contemporary architectural workflows. It distinguishes fully immersive VR head-mounted displays, validated as powerful tools for spatial cognition and stakeholder engagement (Sherman & Craig, 2018), from desktop or CAVE-style VR, mobile AR overlays that align BIM data on-site (Park et al., 2013), and optical see-through MR headsets that deliver hands-free assembly guidance. It also notes low-cost 360° panoramas, browser-based WebXR, and digital-twin XR dashboards that stream live building data. Together these tools shift architecture from static representation to interactive, data-rich environments, as recent campus co-design research confirms (Malakhatka et al., 2025).

Table 1. Key Extended-reality (XR) Modalities and Typical Architectural Applications.

XR modality	Representative platforms / tools	Primary purpose in architectural workflow	Typical use case
Immersive VR (HMD)	Oculus Quest 3, HTC Vive Pro 2 + Unity / Unreal	Full-scale design review; client walk-throughs; ergonomic checks	Virtual mock-up of a hospital operating theatre to test equipment layout and staff circulation
CAVE / multi-wall projection	CAVE2, Igloo Vision domes	Collaborative, room-scale evaluation with multiple viewers	Design studio reviews stadium sight-lines and crowd flows in a 1:1 projected environment
Desktop-based real-time VR	Enscape, Twinmotion, Lumion RT	Rapid iteration inside BIM; lighting and material tweaks	Real-time daylighting tests for a residential interior before specifying finish colours
Augmented Reality (mobile / markerless)	ARKit, ARCore apps (Fologram, SketchUp Viewer)	On-site overlay of BIM elements; clash detection; client previews	Façade panels visualised at 1:1 on the construction site to verify alignment and tolerance
Mixed Reality (optical see-through)	Microsoft HoloLens 2, Trimble XR10	Hands-free assembly guidance; in-field BIM interrogation	Mechanical subcontractors follow holographic pipe routes during installation to reduce rework

Table 1. Key Extended-reality (XR) Modalities and Typical Architectural Applications. (continued)

XR modality	Representative platforms / tools	Primary purpose in architectural workflow	Typical use case
360° stereoscopic panoramas	Pano2VR, VRTourviewer	Low-cost remote walk-throughs; marketing visualisations	Developer shares a 360° tour of apartment units with prospective buyers before construction
Web-based XR (WebXR / WebVR)	Mozilla A-Frame, three.js WebXR	Browser-accessible immersive experiences without installs	Public-participation portal lets citizens explore a proposed park redesign and leave feedback
XR-enabled digital twin	Unity Reflect, Bentley iTwin + VR/AR	Real-time operations monitoring; performance simulation	Facilities team views live HVAC sensor data in a VR model to optimise thermal zoning

In conclusion, the ethical dimension of immersive architecture is about extending the architect's duty of care from physical spaces to virtual experiences. When architecture straddles the real and the virtual, authorship is not just about who designs a space, but who stewards the experience and well-being of its inhabitants across both domains. The notion of authorship here intertwines with custodianship: architects (along with software developers) become custodians of environments that can deeply affect users' perception and behavior. This responsibility demands foresight and moral deliberation akin to that which accompanies designing a public building, but amplified by the unpredictability of user-driven content and the power of simulated realities. As architects embrace XR tools for both design and presentation, they also must advocate for user rights and ethical standards, ensuring that the immersive futures we build are as humane and enriching as the best of our physical environments.

5. Normative and Institutional Reorientations in Architectural Ethics

The evolving scenario of distributed, technology-mediated authorship in architecture calls for a reorientation of the normative frameworks that govern design practice. By normative, we refer to the legal rules, professional codes, and ethical vocabularies that establish what is acceptable and desirable in architectural creation. Many of these norms were formulated under the assumption of human-centered authorship and clear delineations between designer, tool, and user. In light of AI and immersive technologies, these assumptions must be revised. This section proposes key areas of reorientation: clarifying intellectual property and attribution in AI-assisted design, updating professional and legal accountability structures, addressing bias and fairness in algorithm-driven processes, and articulating a new ethical vocabulary that captures the ontological entanglements discussed earlier. In doing so, we align with a larger movement in the built environment disciplines toward proactive engagement with emerging technologies, ensuring they are integrated in ways that uphold human values, equity, and creativity rather than undermining them.

Table 2 maps a concise intellectual trajectory: from Alberti's Renaissance idea of lineaments as abstract design code, through 20th-century notions of hyperreality, autopoiesis and rhizomatic networks, to contemporary theories of ontological design, algorithmic notation and the EU Artificial Intelligence Act, showing how each milestone progressively decentralizes the figure of the lone architect and reallocates agency among humans, data, algorithms, and immersive media. By aligning these theories with landmark empirical studies (e.g., VR spatial-cognition research) and emerging regulation, the timeline clarifies how hybrid authorship has evolved from a conceptual possibility into a pragmatic, legally framed design reality powered by AI and XR.

Table 2. Key Milestones in Hybrid Authorship.

Period	Concept / Theory	Key proponent(s)	Core idea	Relevance to AI / XR design
1450s	Lineaments	Leon Battista Alberti	Design is first perfected mentally as an abstract “line” before construction	Establishes authorship as notation – a precursor to computational modelling
1568	Disegno	Giorgio Vasari	Drawing / design is the “parent” of the three arts	Frames authorship as intellectual, echoed in digital sketch-to-build workflows
2006	Ontological Designing	Anne-Marie Willis	Design recursively makes, and is made by worlds	Main lens used in the paper to explain hybrid authorship with AI/XR
2009	Redirective / Design Futuring	Tony Fry	Design must redirect unsustainable trajectories	Grounds the ethical duty sections on sustainability and responsible AI
2010	Digital Notational Paradigm	Mario Carpo	Algorithms extend Alberti’s notational mindset into copyable code	Bridges Renaissance authorship to generative and parametric design
2016	VR Ethical Code	Madary & Metzinger	First systematic list of VR risks and mitigation guidelines	Source for the manuscript’s section on psychological comfort and manipulation
2018	Spatial-cognition VR studies	Sherman & Craig	Immersive VR enhances understanding and engagement	Empirical basis for claiming design-review benefits of HMD-based VR
2024	EU Artificial Intelligence Act	European Parliament & Council	Risk-based rules; bans subliminal or manipulative AI	Provides the legal frame for XR persuasion and disclosure obligations

One immediate normative challenge is redefining authorship in legal terms. As noted, current copyright and patent laws in most jurisdictions do not recognize AI as an author or inventor; only humans (or organizations as legal persons) can hold such rights (Masood, 2025). Therefore, by default, any design generated with AI is legally attributed to the human(s) who directed the process. This default provides clarity but may not reflect the perceived reality of creation. As architects collaborate with software that has significant creative input, they might feel that traditional sole authorship claims ring false, yet there is no mechanism to, say, list an AI as co-author on official documents or awards. Moving forward, professional institutions and contract protocols may need to explicitly acknowledge AI contributions. The American Institute of Architects, for example, is examining how standard contract documents and attribution guidelines should adapt. One possibility is to credit the creators of generative algorithms in project descriptions (much like one credits a specialist consultant) e.g., “Design by X Architects using Y Generative Design System (developed by Z).” Scholarly publishing is already setting a precedent: new editorial policies require authors to name any generative-AI tools or models that shaped a submission, treating the algorithm as a traceable contributor alongside human co-authors (Kaebrick et al., 2023; Hosseini et al., 2024). Extending that logic to building contracts would clarify accountability and intellectual-property boundaries whenever an architect relies on proprietary code or third-party training data. This approach maintains transparency about the process and gives credit to toolmakers without assigning them legal authorship. Another possibility is developing new licensing models for AI-generated design content, where architects license outputs from an AI (especially if using a third-party service) similar to how stock images are licensed (AIA Contract Documents, 2024). In any case, clarity is needed to prevent disputes. If a

firm uses an AI platform to generate a façade pattern, and later a very similar pattern appears in another project via the same AI, who has the right to that design? Such scenarios could challenge the notion of originality. Some legal scholars propose introducing a *sui generis* right (a unique new category) for AI-generated works, or expanding the concept of joint authorship to include non-traditional contributors under a human's legal stewardship (AIA Contract Documents, 2024). Until such changes occur, architects should be prudent: documenting their role in guiding AI (to show sufficient creative input, which is often required for copyright), and negotiating tool usage agreements that clarify ownership of results. Normatively, the profession also might consider guidelines for giving moral rights acknowledgment to algorithmic contributions, even if not required by law, as a matter of professional ethics and collegiality with the tech industry.

Distributed authorship implies distributed responsibility, yet the law still will hold humans, not algorithms, accountable for failures, especially in architecture where buildings affect life safety. If an AI-generated structural design proved unsafe, liability would fall on the architect and engineers who approved it, not on the software vendor (generally protected by software licenses). A sensible reorientation is to reinforce the duty of professional judgment when using AI. Regulators such as state architecture boards or the ARB in the UK may issue guidance that any AI outputs affecting health and safety must be reviewed and validated by a licensed professional. This mirrors how senior architects check junior designers' work, only here the junior is an AI agent. The standard of care for a reasonably prudent architect will expand to include responsible AI use. In malpractice disputes, architects may have to show they vetted AI recommendations, understood limitations, and independently verified critical aspects. Best practices likely will include audit trails of design decisions by saving versions and AI inputs to demonstrate due diligence. Contracts may add disclaimers that explain AI's role, benefits, and limitations, while affirming continuous professional oversight. Some advocate for algorithmic transparency, for example disclosing extensive AI use in project documentation or to clients, similar to flagging a novel construction technique, so stakeholders understand the innovative and potentially uncertain nature of the process (AIA Contract Documents, 2024). Architects also may press developers for clearer standards and certification, such as seals indicating a generative tool has been tested for code compliance or that an AR construction tool includes safety locks. Since authorship may be shared but responsibility is not, architects must keep tools within supervisable bounds or pursue new models of shared accountability. One possible direction is to treat AI like an employee or subcontractor, raising the question of whether a model's training bias could be analogous to employee negligence, an idea that is speculative but signals where legal theory might evolve.

As noted, AI can inadvertently introduce biases – whether in aesthetic style, spatial configuration, or user assumptions. Normatively, the field of architecture must uphold values of inclusivity and cultural responsiveness. This means that the datasets and algorithms used should be critically evaluated. For example, if a housing design AI was trained only on Western models, deploying it blindly in an Asian or African context could yield inappropriate solutions. There is a push for diversifying training data and for creating open, inclusive datasets for design that represent varied cultural and climatic contexts. Researchers and practitioners could collaborate on an “open architecture corpus” that is consciously curated for diversity, which ethically-minded firms might choose over proprietary biased datasets. Additionally, algorithmic auditing could become a standard practice: independent experts reviewing a design AI for bias or unintended exclusionary patterns (such as layouts that assume nuclear family living arrangements, thereby marginalizing other living forms). Such audits even could be mandated in large public projects: akin to environmental or social impact assessments, we might see algorithmic impact assessments for projects heavily reliant on AI. The normative stance should be that use of

AI does not absolve designers from the obligation to create spaces that are accessible and appropriate for all users (as per ADA standards, etc.), and indeed extra care might be needed to check that AI suggestions do not inadvertently violate these obligations. Professional guidelines might soon include clauses like “Members should ensure that any AI systems used in design are evaluated for fairness and inclusivity, and should correct any biased outcomes”, extending existing ethical canons of the profession (such as the AIA Code of Ethics which calls for social responsibility and non-discrimination in work). In architectural education too, curricula are beginning to include AI literacy combined with ethics, so that emerging architects are equipped to question and guide the technologies they will use.

Beyond self-regulation, government policy is catching up to AI. The European Union’s proposed AI Act, for instance, classifies AI systems by risk and likely will impose requirements on “high-risk” systems including those used in infrastructure design or building safety. If a generative design tool falls under such a category, it may need to meet standards of transparency and robustness, and architects using it might need to follow certain usage protocols mandated by law (such as informing clients that AI was used, or retaining human final decision authority). Meanwhile, building codes and standards could be updated to accommodate design methods. One could imagine future building code commentary acknowledging AI-assisted optimization as a valid method for compliance, as long as outcomes meet performance criteria. Conversely, codes might set boundaries (for instance, disallowing AI-only structural analysis without a licensed engineer’s sign-off). Attribution in the public record is another angle: should a significant AI contribution be recorded when a project is published or archived? The tradition in architecture is to credit the firm, sometimes individual designers, and consultants. Perhaps “software” will be a new category of credit in project descriptions. This already is the case informally in digital design competitions where teams list the tools used. Formalizing it both could acknowledge the creators of those tools and maintain an honest historiography of architecture’s evolution.

Underlying these concrete measures is the need for a new vocabulary to discuss authorship and ethics in this complex milieu. Terms like “architect of record” might evolve into “designer of record” for the human responsible party, distinguishing from generative contributors. Concepts such as co-authorship, co-creation, and distributed agency need operational definitions in practice. The field might adopt terms from computer science like “human-in-the-loop design” to emphasize that humans remain actively engaged when AI is used. Alternatively, philosophical terms like sympoiesis (collective making) or assemblage could filter into design discourse to describe multi-actor authorship. Importantly, the ethical principles that guide decisions need to be articulated in a forward-looking way. We might speak of authenticity in design not as singular authorship but as transparency of process and clarity of intention across a human-machine partnership. The notion of authorship as stewardship could replace authorship as ownership, suggesting that architects, rather than owning a design outcome outright, are stewards of a creative process that involves many forces. In line with ontological design, a term like entangled responsibility might describe how various stakeholders (including technology providers) have intertwined duties for a project’s success and safety. By developing and using such vocabulary, the architectural community can better frame its expectations and norms. For instance, if we say an architect is a “curator of algorithmic creativity,” it implies a normative stance that they should exercise judgment akin to a curator, which includes ethical curation (selecting what is appropriate, discarding what is not).

Finally, professional organizations and educators are starting to write the first charters and manifestos around these topics. For example, a hypothetical “AI in Architecture Ethical Charter” could include points like: “augment do not automate the designer’s conscience,” “ensure traceability of design decisions,” “promote

diversity in algorithmic design practices,” “honor human creativity and cultural context,” and “commit to user well-being in immersive experiences.” These principles would provide direction as the rules and laws catch up. Already, some avant-garde design firms have internal policies: they might avoid using AI for certain culturally sensitive design tasks, or require a diverse team to review AI outputs for biases. Sharing and codifying these practices will accelerate normative evolution.

In summary, normative reorientation entails adapting our rules and language to reflect a reality where architectural authorship is augmented and shared with AI systems and where immersive environments expand the reach of design. It means updating legal frameworks for attribution and liability, strengthening ethical commitments to equity and transparency, and crafting a new ethos for the architect not as the lone genius but as the ethical coordinator of complex creative assemblages. This reorientation is essential to ensure that the profound technological changes at hand lead to positive outcomes: innovative architecture that remains accountable, fair, and deeply human at its core, even as it transcends the human-centric paradigm of the past.

6. Conclusion

This review has traversed the shifting landscape of authorship and ethics in the context of AI-driven and immersive architectural environments. By examining historical precedents, posthuman theory, computational design innovations, and emerging ethical questions, we have constructed a transdisciplinary narrative that converges on a central insight: the concept of authorship in architecture must be reframed for the posthuman era. No longer anchored in the solitary genius of the individual architect, authorship now unfolds as a distributed phenomenon, one that is co-produced by networks of human and non-human actors, from algorithms and datasets to users and interactive environments. This reframing does not diminish the role of the architect; rather, it recasts the architect as an orchestrator of collaborative creativity and a guardian of ethical design intent within a broad socio-technical assemblage (El Moussaoui, 2025a).

Through a posthuman and ontological lens, we recognize that architects “design for, with, and by” an ecology of agents (Willis, 2006). The architect’s vision is mediated by AI tools which bring their own patterns, by the material agency of environment which can surprise and resist, and by the active participation of those who experience architecture in mixed realities. In this entangled state, authorship becomes less a point of origin and more a continuum – a continuous process of negotiation, curation, and adaptation. We design our tools and environments, and they in turn design us as Willis (2006) aptly noted. The authorship of a work of architecture, therefore, is not a moment of creation but an ongoing conversation across time between intentions and outcomes, involving multiple contributors. Embracing this reality invites an ethic of humility and openness in design: humility in acknowledging the contributions of others (including machines and users), and openness to outcomes that were not preconceived. It also encourages innovation, as architects comfortable with distributed authorship are more likely to engage generative AI or participatory platforms boldly, seeing them not as threats to originality but as extensions of the design milieu.

This article offers a broad overview rather than an exhaustive survey, so some relevant work may have been missed. In order to keep pace with fast-moving practice, it mixes peer-reviewed research with policy notes and industry reports; these add freshness but vary in reliability. Evidence is uneven across topics: parts of the discussion rely on studies from human–computer interaction and AI governance rather than architecture-specific trials, which limits direct transfer to building practice. Finally, both the technology and its legal framework

are changing quickly. As new AI tools, immersive devices, and regulations emerge, some details here may date rapidly, so the findings should be revisited and updated on a regular basis.

Ethical responsibility remains human: even when creativity is distributed, accountability cannot be outsourced. Architects and planners must steward AI systems, audit biases, centre human welfare, and protect user rights and well-being (Sunil, 2024; Raja & Al-Baghli, 2025). A normative shift in laws, professional standards, and education is needed, built on transparency about algorithmic processes, equity that widens participation, and sustainability that advances ecological and social resilience in the spirit of Tony Fry's call to design futures that endure. Within a posthuman ethics, sustainability is ontological: designers and the environments they shape are inseparable, so caring for those environments is self-care, echoing Braidotti's vision of transspecies and planetary solidarity (Softaoglu, 2022).

By reframing authorship as ontologically entangled, we acknowledge that design is an open system. In practical terms, this could foster more interdisciplinary collaborations: architects working with computer scientists, cognitive psychologists, and ethicists in the conception of design tools and environments. It also could lead to new design methodologies, for instance, iterative loops where AI-generated variants are critiqued in community workshops (combining algorithmic and participatory design), symbolizing a fusion of machine intelligence and collective human intelligence. An empirical campus case illustrates this hybrid loop: workshop co-designed spatial concepts for sustainable and inclusive university campus environments were translated into interactive VR scenes and then evaluated by heterogeneous stakeholder groups, with feedback used to iteratively refine the proposals (Malakhatka et al., 2025). The result is a jointly authored scheme whose formal language is partly algorithmic, partly crowdsourced, blurring the boundary between designer, tool, and public stakeholder. Such multi-layered loops push the authorship debate beyond simple "AI assist" towards truly co-evolutionary practice. The outcome of such processes is not the vision of a single author, but a tapestry of insights woven together. Architectural theory, too, may develop new models to describe authorship; perhaps borrowing concepts from music (the idea of a remix or sampling might describe how AI reconfigures existing styles into new compositions) or from law (the idea of commons might describe shared creative resources for design).

Ultimately, the reframing we propose is optimistic. It suggests that architecture, as it has many times before, is expanding its boundaries: now into cybernetic and virtual domains, and in doing so, it is reinventing its creative identity. Just as the discipline once absorbed industrialization, then modern computation, it can absorb AI and XR by transforming its notion of authorship from a rigid hierarchy into a fluid network. The architect of the future might be seen less as an author in the old sense and more as a conductor of an orchestra, where some instruments are human and some are AI, together producing a complex symphony of design. The score of this symphony is guided by ethical commitments: the well-being of users, the inclusion of diverse voices (human and non-human) in design, and the aspiration to create physical, digital, or hybrid environments that enrich the human experience while respecting the broader living world.

Figure 1 distils the argument into six concentric layers, moving from the core concept of shared (or distributed) authorship to the legal, ethical, and research horizons that frame AI-enhanced practice.

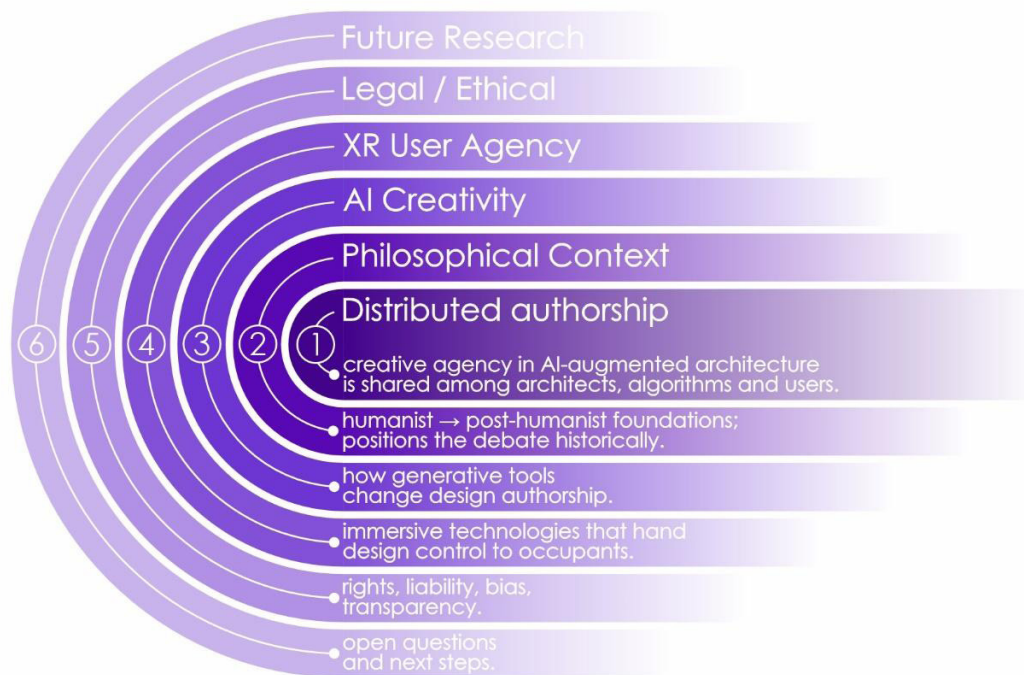


Figure 1. Layered framework of distributed authorship in AI-driven architecture.

Source: by Author

At the centre (Layer 1) is distributed authorship, the finding that creative agency in AI-augmented design is jointly exercised by architects, algorithms, and end-users. Layer 2 situates this shift within a move from humanist to post-humanist thinking, supplying the historical lens that grounds the debate. Layer 3 highlights how generative and parametric tools reconfigure authorship by automating or co-evolving design iterations. Layer 4 foregrounds immersive technologies that transfer certain design decisions to occupants, thus enlarging the author pool in real-time. Layer 5 groups concern over rights, liability, bias, and transparency that arise once agency is redistributed among human and non-human actors. Finally, Layer 6 sketches future research, mapping open questions that must be addressed to consolidate the field.

In closing, the transdisciplinary synthesis offered in this review, which spans ontological philosophy, computational design, immersive technology, and normative theory, points toward a new ethos for architectural creation. We advocate for “posthuman authorship” not as a loss of human creativity, but as an expansion of it. It distributes creative agency in ways that can unlock unprecedented innovation and adaptability, as long as it is coupled with a robust ethical framework. The task ahead for practitioners and scholars is to further develop this framework: to write the manuals, codes, and theories that will guide architects in working harmoniously with AI co-creators and immersive canvases. In doing so, the field can ensure that the reframing of authorship also reframes architecture’s enduring purpose – to imaginatively yet responsibly shape the places we inhabit, whether in brick or in binary, for the flourishing of all.

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Use of Generative Artificial Intelligence (AI) and AI-Assisted Technologies

During the preparation of this manuscript, ChatGPT was used to check the grammatical accuracy of the text. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

Author Contributions

Nataliia Vergunova: Conceptualisation, Methodology, Investigation, Formal Analysis, Visualization, Writing – Original Draft, Writing – Review & Editing.

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