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TRUE ENOUGH RENDERINGS?

The Ethics of CGI Visualizations in Urban Design through Nelson Goodman and Catherine Elgin's Lens

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Abstract

CGI visualizations are central to decision-making in the built environment but are often criticized for their potential to mislead, especially when the projected outcomes do not align with the final built reality. Unlike most CGI applications in entertainment, which rely on similar visual techniques but lack epistemic stakes and truth value, visualizations in urban and environmental planning raise significant ethical concerns. These concerns are particularly acute as they influence public perception and trust. As CGI visualizations advance in aesthetic realism, technological developments, and their capacity to shape public decision-making, addressing these issues becomes increasingly urgent. Drawing on the philosophical work of Nelson Goodman and Catherine Elgin, this paper examines how their concepts of projections, relevant conditions, and "true enough" models illuminate the complexities and ethical concerns surrounding CGI visualizations. By applying these frameworks to visualizations of public projects, the study explores the epistemic and ethical challenges inherent in projecting future environments through digital media.

1 INTRODUCTION: FRAMING THE PROBLEM OF VISUALIZATIONS

Computer-generated imagery (CGI) visualizations have become increasingly ubiquitous in urban design due to their ability to depict realistic images of future constructions. These visualizations, situated within the broader category of 'renderings', are essential tools for stakeholders, particularly in subnational governments, as they convey a proposal's appearance and atmosphere, influencing decision-making processes. However, significant issues arise when visualizations are perceived by the public as surrogates for physical sites, especially when the completed projects deviate from their CGI representations. Beyond public disappointment, these discrepancies have already led to project shutdowns and resignations, underscoring their serious impact on urban development. In these instances, the deviation between visualizations and their constructed counterparts has crossed a threshold, fostering perceptions of manipulation and deceit.

This paper employs theories developed by Nelson Goodman and Catherine Elgin, in Fact, Fiction, and Forecast and True Enough, respectively, as a lens to examine the ethical implications of digital representations of the urban built environment. Much as in their work, the aim is not to provide solutions but to focus on revealing and understanding the complexities of the problem. By applying these frameworks to visualizations of public projects, the study explores the epistemic and ethical challenges inherent in projecting future environments through digital media.

There is a broad consensus on how renderings are generally defined. Their primary purpose is to translate project data into a relatable and understandable format, making them accessible to non-specialist audiences[1] (Lovett et al., 2015, p. 86; Raaphorst et al., 2020, p. 164; Wergles & Muhar, 2009, p. 171). This contrasts with architectural drawings, which such an audience can view as too complex or abstract to grasp (Lewis, 2012, p. 551). Furthermore, they have been characterized as projective visual tools, suggesting how a design might behave within its intended context and anticipating how a project will appear in the future (Sheppard, 2012, p. 352). Scholars have likened this characteristic to a form of clairvoyance, referring to them as "crystal balls" (Sheppard, 2001) or as images of "that-will-be" (Houdart, 2006).

However, in practice, the understanding of renderings, particularly CGI visualizations, is considerably more complex. There is little consensus on how they should be interpreted or on how to assign them to a single epistemological domain: are they better understood as artistic illustrations and visual thought experiments, or as scientific models and predictive tools? Across the literature, visualizations have been described within this range, revealing a fundamental ambiguity in their framing.

CGI visualizations, especially, tend to be framed (or aspire to be framed) as technical models of prediction, expected to embody data precision and accuracy (Lange, 2011, p. 405; Lovett et al., 2015). For example, Stenslund differentiated 'collage' types of visualization from CGI visualizations: the former being more imaginative, aesthetic, and atmospheric, while the latter is expected to be more precise and closer to "[matching] reality" (Stenslund, 2021, p. 2768). Loukissas (2012, p. 18) likewise described this process of "[replicating] some of the conditions of built environments, including material behaviors and perceptual phenomena, for purposes ranging from creative exploration to public explanation" as fitting into the category of 'simulation'. Accounts show that CGI visualizations frequently rely on data such as plans, massing studies, GIS resources, climate analysis, and official 3D models from architects in their

[1] Research by Vermeersch and Heylighen, however, reveals the limitations of this notion of accessibility, showing that the reliance on visual tools can exclude people with visual impairments (Vermeersch & Heylighen, 2021).

production (Degen et al., 2017; Sheppard, 2012). They also highlight the importance of portraying accuracy in scale, views, and structural content (Downes & Lange, 2015, p. 145). In this sense, CGI visualizations are embedded with elements of simulation in order to produce predictive, realistic models that are later output as images, videos, or real-time interactive content. Degen et al., in their ethnographic work, describe them as lying in an ambiguous territory between portraying 'invented worlds' (Degen et al., 2017, p. 14) and being grounded in truth and data.

These accounts demonstrate the epistemic complexity of CGI visualizations. They can be, and have been, framed as models, simulations, visual thought experiments, or aesthetic depictions, fitting into multiple interpretive categories. Nonetheless, their stated primary purpose is not aesthetic. At least in principle, they are intended to inform by offering a visual forecast. This capability has become a double-edged sword: on the one hand, CGI visualizations are used to influence decision-making and garner support for projects; on the other, ethical issues are raised when there are discrepancies between the predictions and the built outcomes, and they have been criticized as unethical, deceptive, and overly persuasive.

Concerns about visualization's potential to mislead are prominent in the literature. A 2012 publication featuring short essays on renderings highlights this critique, with architecture critics labelling such images as fake (Sigg, 2012, p. 36) and comparing them to porn (Sériès et Sériès & Labtop, 2012, p. 27) and movie trailers (Tsu, 2012, p. 106). The publication identifies several problems associated with visualizations, by relying on comparisons between constructed outcomes and their corresponding projections to emphasize discrepancies. For the authors, visualizations are often careless and overly misleading.

Similar criticisms of visualizations have been laid out by other scholars. Stephen Sheppard, for example, has claimed that unreliability and data inadequacy in visualizations were principal factors in their potential to "mislead the viewer" (Sheppard, 2001, p. 187). Luymes and McDonald have argued that a visualization's degree of realism increases the tendency for viewers to perceive it as accurate and factual (McDonald, 2012, p. 33; Sheppard, 2001, p. 190). In other words, the more believable the elements depicted, the greater the likelihood that viewers will trust the visualization, regardless of the reliability of the underlying data.

Such conflation of visual believability with accuracy is further reinforced by the tools used to create these images. Many CGI visualization tools originate from the entertainment industry, whose primary goal is to produce convincing visual solutions (Alexander & May, 2020, p. 32; Loukissas, 2012, p. 75) . To achieve this goal, these tools have been programmed with artificial "hacks" and shortcuts designed to reduce costs and computing time, prioritizing visual believability over accuracy (Alexander & May, 2020, p. 43).

Today, with significant advancements in the quality, accessibility, and proliferation of digital visualization tools, the problems highlighted by scholars have become increasingly pronounced, manifesting themselves in large-scale, real-world cases. A notable example is the Marble Arch Mound in London, designed by MVRDV. The project's approval and public anticipation were heavily shaped by its compelling renderings. However, when the mound was unveiled in 2021, it failed to meet these expectations. This led to widespread disappointment, temporary closures, and even resignations, with media coverage frequently highlighting the contrast between visualization and construction to the project's poor reception (Luz Rodrigues, 2025). The controversial project underscores how persuasive renderings can shape public expectations, and how significant the consequences can be when the result diverges too drastically from the realistically envisioned image.

Efforts have been made to counter or at least mitigate the ethical issues that arise from the lack of transparency in visualizations. In 2001, Sheppard asserted that "ethics and truthfulness" were

necessary policy issues for the field of visual simulation, and proposed an “interim code of ethics” (Sheppard, 2001, p. 189). Over a decade later, Downes and Lange would endorse the creation of similar guidelines (Downes & Lange, 2015, p. 145). Industry companies have adopted more practical solutions, such as “Accurate Visual Representations” (AVR), a purportedly more rigorous and ethical visualization method aimed at depicting designs “exactly as they will appear in situ”(Reidel, 2012, p. 24). The AVR process involves an independent team visiting the site with measuring devices and taking unedited, amateur-style photographs of the existing location. These images are then overlaid with a 3D visualization of the proposed building onto the photograph, avoiding any additional image retouching. Reidel notes that, although the result is lackluster and that it is difficult to interpret the given proposal (e.g., elements not standing out), “at least the public has a better sense of what to expect (Reidel, 2012, p. 24).

While these practical efforts have been valuable, they still do not counter some of the underlying issues related to CGI visualizations in urban design. Even if one were to adopt and refine the proposed guidelines, fundamental problems would persist. For example, in Sheppard’s guideline, he mentions that “Visualizations should simulate the actual or expected appearance of the landscape” and should represent “important views/conditions of the landscape” (Sheppard, 2001, p. 194). In terms of ethical aspirations and goals, it is undeniable that they should. However, what constitutes a site's “actual” or “expected” appearance? Isn’t this very ambiguity — regardless of intent — one of the main concerns in the first place? Furthermore, determining what constitutes "important views" is a politically and culturally charged matter. Who decides which views are prioritized, and which perspectives are excluded, involves complex questions of authority and representation. Similar to the longstanding debates in cultural conservation, such decisions reflect power dynamics and often marginalize certain narratives. AVR is not an exception. It speciously conveys neutrality. It can, for instance, have an effect similar to the ethical issues with visualizations, but in the opposite direction: transforming a landscape that is perceived as beautiful into something mundane and uninspiring.

Thus, the problem persists. The proposed solutions, while well-intentioned, fail to address the root causes, suggesting that perhaps the issue lies in how the problem itself has been framed. The more one delves into the problem, the more one realizes that it may not be a purely technical problem, but a philosophically-rooted one.

2 PHILOSOPHICAL PERSPECTIVES ON PROJECTIONS AND MODELS

The seemingly unsolvable questions in visualizations echo the challenges explored by philosophers Nelson Goodman in *Fact, Fiction, and Forecast* and Catherine Elgin in *True Enough*. Both authors grappled with the epistemological complexities of projections and the representation of predictive models, shedding light on the inherent challenges in determining validity in representations. How can a depiction sufficiently resemble something that does not yet exist? And what criteria define "sufficient resemblance"? Similar to the question of what constitutes an actual or expected appearance in a CGI visualization, Goodman wrote: “A valid projection is, admittedly, one that is in agreement with past regularities in what has been observed (...) the difficulty has always been to say what constitutes such agreement” (Goodman, 1983, p. 21).

Although their works primarily focus on scientific models rather than CGI visualizations of landscapes, their underlying premises share significant parallels, particularly through two key concepts: Goodman’s *Relevant Conditions* and Elgin’s *True Enough*. How do these frameworks apply to contemporary problems associated with CGI visualizations, and how might they offer deeper insights into the challenges posed by the use of such creative technologies?

3 RELEVANT CONDITIONS

In Fact, Fiction, Forecast, first published in 1955, Philosopher Nelson Goodman presented and analyzed the complexities and paradoxes that arise when attempting to define induction and projection processes. A key philosophical concern of the publication is well-summarized by his protege Catherine Elgin:

> *"Induction involves projecting from a limited body of evidence. But every body of evidence belongs to a multitude of wildly divergent extensions. To which of them ought we project?" (Elgin, 2001, p. 687)*

At the same time, Goodman points out that this same logic of questioning inversely applies: how does one decide what not to project and to therefore eliminate "unwanted hypothesis"? (Kahane, 1965, p. 378).

Goodman acknowledges that resolving these challenges is an exceedingly difficult task (Goodman, 1983, p. 21). He introduces this problem in the first chapter of his publication by examining counterfactual statements. Counterfactuals, in colloquial terms, are statements describing "what if" scenarios. A typical example might be: "If A were to occur, then B would ensue." Karvanen et al. provide a more precise definition, describing counterfactual inference as "a hypothetical intervention in a parallel world that shares some evidence with the factual world" (Karvanen et al., 2024, p. 835). Conceptually, this belongs to the same family as a thought experiment, which Elgin describes as "an imaginative exercise designed to investigate what would happen if certain conditions were satisfied" (Elgin, 2017, p. 235).

These descriptions hinge on essentially the same structure: a speculative or fictional premise, followed by a seemingly plausible rationalization of the consequences that would follow. Goodman observes that the latter must adhere to what he terms "truth-functional compounds" for the statement to hold (Goodman, 1983, p. 4). These compounds, he argues, must satisfy certain lawlike conditions and reject impossible or contradictory scenarios to maintain the validity and plausibility of the counterfactual (Goodman, 1983, p. 4). In other words, while a suspension of disbelief is necessary to accept the hypothetical premise (e.g. roleplay) (Elgin, 2017, p. 235), suspension of belief is unacceptable when interpreting the consequent. To do so would likely undermine the coherence of the statement as a whole.

A hypothetical such as "if all walls became transparent" (whether in verbal or visual form) is acceptable as a speculative starting point, as is any other. However, a consequence such as "...they would provide more privacy" would be inherently contradictory; transparency and privacy are fundamentally at odds, making the statement a priori illogical outcome. Undoubtedly one would refute such a depicted outcome, asserting that the opposite effect would occur. Thus, while there is a degree of openness in accepting even the most absurd hypothetical, there is rigidity and scrutiny when evaluating the validity of the projection.

Goodman further notes, however, that even when adhering to seemingly plausible laws, wrongful projections can still occur. He provides an example showing how a hypothetical scenario may yield two opposing but equally plausible outcomes: if an unscratched match had been scratched...," both "...it would have lighted" and "...it would not have lighted" are possible consequences (Goodman, 1983, p. 14). Neither outcome seems unimaginable and yet they can't both be true. The fundamental issue with this example is that completely disparate projections of the same hypothetical are treated equally as potential truths, which hampers the credibility of trusting any given projection.

According to Goodman, an explanation for why different plausible projections arise in the same given scenario is that there are implicit changes in conditions when assessing the hypothetical. In his example of scratching a match, particular unstated conditions/attributes influence the

match's ability to light, such as whether it is well-made, dry, and surrounded by sufficient oxygen (Goodman, 1983, p. 8). A failure to light is equally plausible if different conditions, such as the match being damp, are assumed. Goodman demonstrates that a projection encompasses far more than the explicit problem; it involves a network of assumptions and conditions. These unstated factors, which he calls "Relevant Conditions," are crucial for forming coherent projections.

However, some conditions are more critical than others. Goodman emphasizes in his match case study that while factors like moisture are vital to a match's ability to light, others, like its color or smell, are irrelevant. Goodman argues that the challenge of projectability lies in identifying which conditions are truly relevant and which are not (Goodman, 1983, p. 27).

Additionally, Goodman also reflects on the role of time in shaping our perception of Relevant Conditions. In *Languages of Art*, he exemplifies this with an observer's inability to distinguish between an authentic painting and a forgery at a given moment:

> "(...)is there any aesthetic difference between the two pictures for x at t, where t is a suitable period of time, if x cannot tell them apart by merely looking at them at t? " (Goodman, 1976, p. 102).

However, after time *t*, new knowledge or evidence may alter this perception (Goodman, 1976, p. 105). From Goodman's perspective, concerns with projections often become clear only in hindsight—after time *t*. The projected image itself remains unchanged throughout; what evolves is our understanding of the assumptions and conditions that shaped it. It is only after time *t*, when the projection phase ends, that these "Relevant Conditions" are fully revealed. These changes not only affect future perceptions but also impact the perception of past experiences. Elgin exemplifies this in the story of Oedipus Rex: Oedipus' discovery of fulfilling the oracle's prophecies "did not just doom his future happiness(...)it discredited his past happiness" as if he had "been living a lie" (Elgin, 2017, p. 239).

"Relevant Conditions" underscores the critical role of hidden factors in shaping outcomes. By acknowledging such factors, we can better grasp the complexity of projections and their outcomes. In *Languages of Art*, Goodman argues that no single, objective representation of a subject exists; every depiction depends on an array of assumptions and conventions. He questions why representations are so standardly framed "to the normal eye, at proper range, from a favorable angle, in good light" (Goodman, 1976, p. 7). These choices, Goodman stresses, are not neutral but are deliberate and shaped by underlying assumptions (Goodman, 1976, p. 8). Understanding these implicit combinations of choices is essential for evaluating the validity and ethics of projections.

4 TRUE ENOUGH

In *True Enough* (Elgin, 2017) Catherine Elgin expanded on many of the concepts introduced by Goodman, particularly regarding acceptability and uncertainty in models and representations. Contrary to the common belief that inaccuracies render models inadequate, Elgin argues that even models with significant discrepancies can be valuable. She refers to such models as "felicitous falsehoods," asserting that they should not be dismissed if they "afford epistemic access to aspects of their targets that are otherwise overshadowed or underemphasized"(Elgin, 2017, p. 2).

Elgin challenges the assumption that greater realism or accuracy inherently leads to better knowledge. She illustrates this point through perspective representations, noting that while visually realistic models may appear precise, they often obscure or misinterpret certain features. For instance, such representations may fail to reveal what lies behind an object or

omit crucial properties altogether (Elgin, 2017, p. 154). As a result, they can distort the perception of their target, even when technically accurate. Whether this misdirection is intentional or accidental is moot; either way, it complicates the presumed correlation between a model's accuracy and its truthfulness.

This critique is significant because it questions the widely accepted notion that increasing realism and accuracy inevitably improves outcomes. Elgin's argument is particularly relevant in contemporary contexts like digital twinning, where the pursuit of hyper-realistic models often goes unchallenged. She argues that "to identify *a* with *b* is not to hold that *a* is identical to *b*," underscoring the distinction between resemblance and representation (Elgin, 2017, p. 23).

For Elgin, the purpose of models is not to replicate their targets in exhaustive detail but to "make salient" and "manifest different features of the target" (Elgin, 2017, p. 249). A model's value lies not in its strict adherence to truth but in its capacity to facilitate understanding. She contends that imprecise or simplified data can be effective and even desirable if it aids in comprehending specific aspects of the target. In her view, it is more valuable to illuminate a crucial aspect of the target, such as a relevant condition, than to emulate countless details that contribute little to understanding. Elgin argues that "epistemic acceptability turns not on whether it is true", but on whether it encompasses the threshold of "true enough"(Elgin, 2017, p. 16). Ultimately, she emphasizes that the epistemic access a model provides—its ability to enhance understanding—is more critical than the precision of its depiction.

5 VISUALIZATIONS AS COUNTERFACTUALS

Goodman and Elgin's formulations of counterfactuals, thought experiments, and models are readily applicable to CGI visualizations. Visualizations similarly require a suspension of disbelief, in which viewers must momentarily set aside the fact that they are presented imaginative depictions, albeit convincing ones, to then evaluate them seriously. They align with Elgin's description of imagining "(...) a situation where the abstract features are realized (...) to investigate what would happen in a virtual reality where certain constraints are supposed to hold" (Elgin, 2017, p. 232). However, as simulation technologies advance, the acknowledgement of this make-believe instance is increasingly overlooked. Scholars warn that as simulations become increasingly immersive, viewers are primed to conflate them with reality, revealing how we remain unadapted to the ambiguities of contemporary imaging technologies (Downey, 2024; May, 2019, p. 19; Turkle, 2019, p. 56) .

Another commonality is that visualizations often face the challenge of offering different projections of the same scenario. Roopali Phadke highlights this matter in a controversial project assessing the visual impact of windmills. In this case, an initial set of visualizations created by one firm was followed by "counter simulations" produced by another firm to identify potential biases and discrepancies (Phadke, 2010, p. 10). Although similar in nature, the visualizations also presented key distinctions in their depictions (Phadke, 2010, p. 10). This is not surprising, as visualization-makers and studios are often noted for employing distinct artistic mannerisms and iconographies to convey atmosphere and representation, as well as highlighting different features. While this signals the presence of artistry and creativity in the visualization process, it also evidences the degree of subjectivity involved, further complicating the reliability and consistency of projection outcomes.

The parameters specified for, or inherent in, a given visualization model, and how differences in attributes alter perceptions, mirror the ethos of Relevant Conditions. In visualizations, commonly acknowledged parameters include weather, time of day, and lighting, but the possibilities are virtually infinite—even details such as a passerby's haircut qualify as parameters.

Goodman's theory of *Relevant Conditions* offers a valuable framework for understanding why some visualizations are accepted while others are heavily criticized. Neither extreme signifies "accurate" depictions, as all visualizations inherently exhibit differences and discrepancies from their eventual constructs. However, particular conditions are either represented or not represented in a way that crosses a threshold of acceptability, triggering criticism. This critique need not even pertain to the constructs themselves, as scholars have identified instances of backlash stemming from the misrepresentation of the people depicted in these scenes, such as failing to reflect their ethnicity, race, or class (Degen et al., 2017, p. 19; Nathaniel Mayer, 2012, p. 31; Ravenscroft, 2018).

As Goodman and Elgin have claimed, some parameters wield enormous influence and scrutiny, while others remain insignificant, even when imprecise. Goodman argues that distinguishing between critical and inconsequential parameters is key. More important than amassing a high quantity of realistic features is the task of identifying and highlighting those that will be regarded as influential and relevant to the viewer's perception and understanding. Indeed, many visualizations have exhibited notable changes from their constructed outcomes without provoking ethical concern, while other projects with comparatively less deviations have nonetheless triggered significant backlash. Goodman and Elgin's theories indicate that what matters is not the magnitude of deviation, but which particular features are subject to change.

This facet, articulated in Elgin's *True Enough*, is particularly relevant today as it mirrors the challenges posed by the increasing prevalence of AI-generated content. While AI-generated images have rapidly demonstrated their ability to produce strikingly realistic visuals, they sometimes fail to capture essential epistemic attributes of their subjects. As visualization industries increasingly incorporate these technologies (Chaos & Architizer, 2025), the issue of sacrificing epistemic accuracy for visual realism, and all its problematic consequences, risks becoming further entrenched.

Like Elgin, Christopher Bardt has argued that the cultural and epistemic value of models in the built environment is not directly proportional to their "optimization" (Bardt, 2022, p. 615). He observes that while digital tools promise "increased affordances" and "creative empowerment," they have also amplified the mismatch between intended and unintended outcomes (Bardt, 2022, p. 610), with the latter consistently treated as errors to be corrected (Bardt, 2022, p. 613). For Bardt, much of their value lies precisely in the creative process demanded to fill the gap between drawing and making (Bardt, 2022, p. 615). As models increasingly approach the predictive assertion of a crystal ball, this gap narrows, reducing opportunities for change and designer engagement (Bardt, 2022, p. 615). This is similar to Turkle's acknowledgement that the output of a simulation is often viewed as a finished work to be portrayed as-is (comparable to a "ready-made") rather than as a preliminary sketch open to interpretation and evolution (Turkle, 2019, p. 57).

Lastly, the importance of identifying the relevance of time and its influence on perception, as highlighted by Goodman, becomes evident in visualizations, where critiques and analyses of unethical representations often emerge only after the completion of a constructed project. At this later stage, hidden assumptions and discrepancies in the visualizations become apparent, as there is a clear reference point for comparison. Rarely are these critiques made beforehand, as identifying faults in visualizations without the benefit of hindsight can be difficult, if not impossible. Perceptual changes, driven by new knowledge gained after the passage of a period of time — usually the construction phase, shape our judgment of acceptability, even though the visualization itself remains unchanged.

This is evident in the numerous essays and publications commonly referred to as "Render vs. Reality" (e.g., Abdel, 2022; Baillieu, 2021; Olsson, 2024). Much like the game of *Spot the Difference*, here, renderings and photographs of constructed outcomes are placed side by side

for a comparative evaluation of their discrepancies. The public often takes issue with the renderings during this moment of comparison with the constructed reality—when the projection ceases to function as a projection and becomes evidence of either accuracy or misrepresentation. Sheppard acknowledges this, writing that "where visualizations are shown to be misleading, as can happen after construction of the project, the resulting public dismay can bring both the preparer and the technique into disrepute" (Sheppard, 2001, p. 192).

6 THRESHOLDS AND ETHICAL IMPLICATIONS

It seems, then, there is a concern that a visualization may reveal itself as damaging after a given period. This period typically culminates with the unveiling of the constructed outcome, which may or may not fulfil the promises of the renders—the latter being what the public or the stakeholders initially consented to. Herein lies one of the most significant ethical concerns: public approval and project agreement often rest on trust in these images. The public places confidence in the hypothetical depictions, treating them as reliable and truthful. It is not unreasonable to assume that failure to meet these expectations breaks this bond of trust, leading to a profound sense of deception. In other words, significant discrepancies that cross a threshold, regardless of intent, have the potential to fracture this trust, leading to far-reaching ethical implications.

Truth and trustworthiness, as described by Elgin, fit within Williams' definition of a 'thick' concept: they are normatively loaded and too complex to be reduced to simplistic labels like "good" or "bad" (Elgin, 2017, p. 123). Elgin argues that benign intentions alone are insufficient to establish trustworthiness, emphasizing the requirement of additional factors. For example, she notes that an agent's lack of competence undermines trustworthiness by increasing the risk of unintentional harmful outcomes. Additionally, conflict of interest also erodes trustworthiness because its mere occurrence is enough to cast doubt on the integrity of the project (Elgin, 2017, p. 136).

Both competence and conflict of interest are issues prevalent in visualizations. Visualizations are shaped by the preparer's varying skill levels (e.g., software proficiency) and by technological limitations (e.g., software constraints). Moreover, visualizations are typically prepared not by a disinterested party, but by proponents of a project—actors with a vested interest in securing approval and ensuring the proposal's success.

Another significant issue arises when visualizers are required to depict elements for which they have little or no prior information. Visualizers Andriy and Vasyl Matsola, for instance, describe how they regularly had to fabricate elements such as landscape planting, façade designs, and furniture entirely from their imagination. "Of course, it's not going to be built like that," they acknowledge (Matsola & Matsola, 2020).

Even without issues such as bad actors, lack of competence, limited access to information, or conflicts of interest, and assuming complete earnestness in the design, "reliable" projections cannot be guaranteed. Acknowledging this inherent complexity of projectability is a core aspect of Goodman's work. Rather than offering oversimplified solutions, Goodman illustrates the profound challenges and intricacies of the matter, emphasizing the fallibility and limitations of even well-informed projections. Elgin echoes this sentiment, noting how even someone confident in their inductive claim may later discover they were mistaken. Such realizations often lead to admissions that seem almost contradictory, such as: "I thought I knew it, but I was wrong" (Elgin, 2017, p. 18).

The question, then, is whether ethical responsibility should be attributed mainly— as it often currently is—to the preparer's handling of the visualization. Given the previous arguments, it seems unreasonable to expect visualizers to act as clairvoyants, and to assume that errors in

their predictions constitute wrongdoing. The issue, we argue, should not focus solely on the errors made by visualizers but rather on understanding and improving the relationship between visualizations and public perception.

For example, Andriy and Vasyl Matsola could distinguish in their depictions between elements that were based on determined attributes and those entirely imagined. They recognized that certain features carried a higher degree of certainty, closer to 1.0 on a scale of confidence, while others, fabricated purely from imagination, were closer to 0.0. However, this distinction was not communicated to the public. Instead, in current practice, the public receives the visualization stripped of these attributes, and as a uniform photorealistic representation. As a result, the public cannot discern the boundaries between certainty and uncertainty, leaving them indistinguishable. This ambiguity is similarly observed by Piedmont-Palladino, who argues that the "representational chiasmus" between digital renderings and photography leaves viewers confused about what they are seeing and how they should evaluate it (Piedmont-Palladino, 2018).

Regardless of the visualizer's competence, this ethical problem will likely persist as long as the visualization-public perception relationship lacks transparency. Elgin acknowledges that variations in threshold acceptance influence the distinction between noise and signal and that such decisions inevitably involve trade-offs—there is no singular optimal resolution. However, the public does not even have access to any information about such decisions. In this ambiguity, everything may be conveyed as signal. This lack of clarity may be central to feelings of deception and mistrust, ultimately triggering public backlash.

5 CONCLUSION AND PATHS FOR FUTURE RESEARCH

We have argued that the epistemic functions of counterfactuals, thought experiments, and projections are directly relevant and applicable to CGI visualizations, as they share a common intellectual lineage rooted in speculative reasoning and the exploration of potential outcomes. Visualizations of landscapes and built environments confront challenges like ambiguity, conflicting projections, and the validity of representations—issues central to Goodman and Elgin's philosophical inquiries. In contrast, similar-looking CGI applications, such as those used in entertainment, lack such lineage. While these entertainment visualizations may employ comparable visual techniques, they are not concerned with projecting possible futures or grappling with epistemic challenges. This stands in stark contrast to the ethical and representational stakes that define visualizations in urban and environmental planning. Recognizing this distinction underscores the value of applying Goodman and Elgin's frameworks to CGI visualizations, which are uniquely tasked with addressing the ethical complexities of projections and their influence on public perception.

Moreover, as visualizations advance in both realism and their influence on public decision-making, they must navigate the ethical dilemmas inherent in projections. This is where Goodman's concept of relevant conditions and Elgin's notion of "true enough" become crucial. CGI Visualizations, as projection models, depend on the complex and often insoluble conditions and assumptions embedded in them. As we have discussed, the public's perception of these representations hinges on these uncertainties. While much of the ethical discourse surrounding visualizations has focused on their failure to adequately project, or how to provide "fixes" for them, we argue for a shift in focus toward understanding the relationship between the visualization and public understanding.

In the current culture of visualization, the public is often left without the necessary tools to distinguish between varying conditions, limitations, and confidence thresholds within these representations. This gap, left unexplored and unaddressed, not only exacerbates ethical

concerns but also fosters feelings of deception and mistrust. Shifting the focus from fault-finding technical errors in visualizations to addressing and ameliorating the relational dynamic between visualizations and public perception could be key to mitigating these ethical risks.

Developing a system that grants the public access to relevant information about visualizations offers a promising way to mitigate these adverse effects. The inaccurate yet "true enough" models exemplified by Elgin succeed, in part, because interpreters are provided with an understanding of the conditions, rules, and limitations—a kind of social contract that informs their perception. Much like when playing the lottery, one does not feel cheated upon losing because the game's conditions and odds are clearly understood beforehand. In contrast, visualizations lack this level of transparency. The public is not given access to the conditions, parameters, or thresholds that shape these projections, yet they are expected to evaluate and make decisions about their environments without clarity on what they are seeing or how it was developed. We argue that the focus should shift from assigning blame to the "errors" of visualizations and instead focus on addressing the gaps between visualizations and how they are interpreted by the public. This gap remains the most nebulous and unexplored aspect of CGI visualizations —and, perhaps, the most ethically troubling one.

Data Access Statement

N/A. This article presents a conceptual analysis based on published sources cited in the text. No research datasets were generated or analysed.

Contributor Statement

Hermano Luz Rodrigues: Conceptualization, Investigation, Writing – original draft.

Patrick Collins: Writing – review and editing, Supervision.

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Use of AI

During the preparation of this manuscript, the author(s) used Grammarly and ChatGPT to proofread the text for grammatical accuracy. After using this tool/service, the author(s) reviewed, edited, made the content their own and validated the outcome as needed, and take(s) full responsibility for the content of the publication.

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