# Treespotting AR ($TS^{AR}$): Re-Enchanting Minimal Phygital Ecologies

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**Abstract:** In times of digital abundance, Treespotting AR ($TS^{AR}$) challenges the hyperrealism of technocratic digital twins and XR applications. Learning from Cesare Leonardi and Franca Stagi's experimental graphics deployed in their seminal work "The Architecture of Trees", $TS^{AR}$ translates their reductionist logic into a monochromatic point cloud installation. By minimizing data to maximize phenomenological engagement, the project explores new forms of mediated encounters with urban nature. Field-tested by 430 participants, the installation demonstrates how abstract visualization can foster reflection about the multiple formalizations of AR while investigating speculative and participative design, proposing a shift from managerial data to embodied, phygital encounters.

**Keywords:** Augmented reality (AR), point cloud, phenomenology, digital twin, landscape representation

## 1 Introduction: The Challenge of Digital Abundance

We currently confront a paradigm shift where new technologies as LiDAR, photogrammetry, and neural rendering, dense point clouds, and Extended Reality (XR) promise unprecedented fidelity and enhanced interaction. However, this "digital abundance" (HOVESTADT et al. 2017) introduces a new epistemological challenge (HELBING & ARGOTA SÁNCHEZ-VAQUERIZO 2023). It makes us question whether ultra-detailed geometry and virtually endless data layers clarify the integration of nature into design, or if they obscure it through "technocratic solutionism".

In this context, we revisit the legacy of Cesare Leonardi and Franca Stagi's "The Architecture of Trees" (1982) (LEONARDI & STAGI 1982) to propose a critical framework for digital representation. We ask: *how can their representational logic, i. e. balancing precision with abstraction, guide the processing of point clouds into meaningful spatial design information in AR, thereby countering the limitations of technocratic digital twins?*

Hence, we present Treespotting AR ($TS^{AR}$), an AR installation that reimagines Leonardi's methodology through contemporary 3D scanning and visualization techniques, challenging conventional representational modes in landscape design. By navigating this specific case study, the project explores the friction between the endless possibilities of digital representation and the grounded contingency of physical reality. Unlike traditional approaches, $TS^{AR}$ is not a drawing, a model, or a photograph; it is a curated sampling of a living entity. $TS^{AR}$ operates as an ontological threshold where traditional categories such as object, space, surface, or boundary, lose rigidity and are renegotiated through phenomenological experience. It is designed to be partial but situated, relational, and performative, existing only within an active relation with the viewer.

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Crucially, a landscape or urban design project, as any design project, is, by definition, a virtual project. The relative indetermination of a design proposal is one of its fundamental features. It is the indetermination of the representation of architectural projects what allows it to "speak", and "be a matrix of possible narratives regarding the kind of built reality it anticipates" (PICON 2004). "Like cyberspace, a designed landscape is always at bottom a fiction, a contrivance – yet its hold on our imagination will derive, paradoxically, from the actual materiality of its invented sceneries" (HUNT 2004). Even though a designed landscape is a 'fiction', its imaginative power stems, paradoxically, from the physical materiality of its invented spaces. Accepting the fictional character of something so "accurate" as a point cloud allows designers to honestly engage with the possibilities it encapsulates.

Etymologically, "data" refers to things that have been given, whereas "information" implies data having been put into form. TS$^{AR}$ enacts this distinction by putting a raw scan into form. It questions the roles of fidelity, accuracy, and completeness, serving not as a final representation, but as the generation of a world in which design thinking can take place.

# 2 Related Work and Theoretical Framework

## 2.1 The Legacy of Cesare Leonardi

To answer the question of how Leonardi and Stagi would work today, one must look beyond the aesthetic of Leonardi and Stagi's drawings to the logic that constructed them. Leonardi and Stagi did not merely illustrate botany. Instead, they proposed a systematic abstraction that distilled the shape of trees, seasonal change, and shadow into scalable diagrams relevant for design, and turning trees into relevant architectural actors rather than mere ornaments (Fig. 1).

However, translating this conceptual clarity into the current digital abundance without falling into digital formalism requires a rigorous theoretical framework. Therefore, the use of the point cloud presented in TS$^{AR}$ is not conceived as raw data, but as a form of "cognitive art" (TUFTE 1990).

**Individualization over Typology**

Leonardi and Stagi refused to draw a generic tree, insisting instead on the specific one they encountered. Their drawings captured not only form but also posture, growth history, asymmetry, and the species' topological branch logic. Each drawing was not a type, but a singular entity, turning drawing into an act of individuation. TS$^{AR}$ adopts this approach. Where some might view the irregularities of a point cloud as noise, here it is seen as the necessary texture of singularity. This aligns with the argument that digital urbanism must move beyond the illusion of "precise data" to embrace the uncertainty of urban, human reality (DELSO GUTIÉRREZ & ARGOTA SÁNCHEZ-VAQUERIZO 2023, CALDARELLI et al. 2023). TS$^{AR}$ uses the point cloud to inhabit a terrain between precision and abstraction, avoiding geometric homogenization common in standard CAD representation of nature, where organic complexity is often standardized into static blocks (M'CLOSKEY & VAN DER SYS 2017).

### Temporal Thickness and the Defense of Complexity

Leonardi and Stagi's work was never a frozen moment, but a relationship of trees over time. This resonates with what Jeremy Till describes as "thick time" understood as a rejection of the instantaneous snapshot in favor of an accumulated temporal reality (TILL 2000). The drawings of "The Architecture of Trees" required attentive and prolonged observation to see time, growth, and particularities. To replicate this depth in a digital medium, it is needed to embrace visual complexity. TS$^{AR}$ leverages the principle that "clutter and confusion are failures of design, not attributes of information" (TUFTE 1990). Therefore, the high density of the point cloud is retained not to confuse, but to allow the viewer to select, edit, single out, and structure the information. This density enables a mediated encounter where the viewer must actively navigate the multi-scalar readings of the tree, just as they would with Leonardi and Stagi's intricate linework.

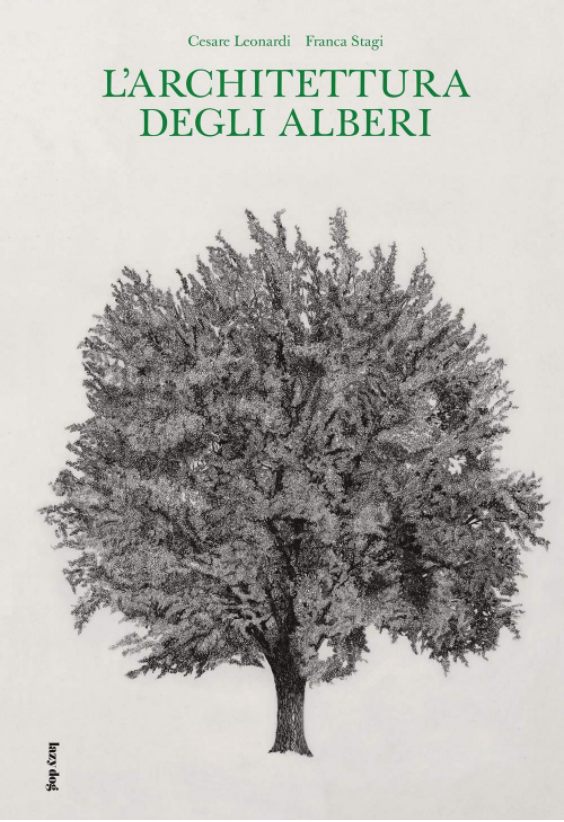


**Fig. 1:**
Cover of the "L'architettura degli alberi" ("The Architecture of Trees") with one of the drawn trees (LEONARDI & STAGI 1982)

## From Documentation to Speculation

Leonardi's drawings inhabit a blurred terrain between documentation (i. e. representation) and proposal (i. e. speculative proposal). They became a space of reflection for practice. Following this, TS$^{AR}$ is proposed not only as a documentation tool, but as a framework for speculation. Rather than considering the point cloud as a managerial asset, TS$^{AR}$ aims at the "phygital" (physical + digital) medium (BAZZANELLA et al. 2014). This approach is simultaneously quiet and rich for perceptual re-examination, and perhaps, re-enchantment (DUNNE 2005). Consequently, it serves as a catalyst for the viewer's imagination, potentially serving as the first entry in a new virtual catalogue, which can be envisaged as a contemporary digital counterpart to Leonardi and Stagi seminal work.

### 2.2 Context: Perceptual vs Managerial Digital Twins

While Leonardi provides the methodological foundation, it is necessary to situate TS$^{AR}$ within the current technological landscape. Recent discourse in Digital Landscape Architecture has mainly framed digital twins as managerial instruments. Urban-scale twins support climate resilience modeling (ZHU & JIN 2025, SALLIOU et al. 2025), biodiversity monitoring (WESTERLAKEN 2024), simulation (CHEN et al. 2024), and real-time environmental sensing. While these systems provide valuable support for green infrastructure management, their representation of trees is often simplified to facilitate calculation (GROMKE & RUCK 2007).

Simultaneously, research on Human-centric, community and participatory design has explored AR as tools for spatial engagement (AHMADI OLOONABADI & BARAN 2023). However, many applications remain constrained to consultation processes, simply overlaying technical data without enhancing deeper ecological fine-tuning. This also resonates with critics pointing out that digital representation does not mean "groundtruthing", as mediation, which digital representation is, always shapes perception (REKITTKE et al. 2021).

TS$^{AR}$ sits at this intersection, leveraging Computation and Digital Technologies to advance perceptual digital twins prioritizing insight over data exploitation. This approach aligns with emerging critiques on "digital solutionism" (MOROZOV 2013). Therefore, TS$^{AR}$ advocates for a relational perception: using digital tools to recalibrate, attune, human awareness of ecological presence.

## 3 Methodology: Workflow and Implementation

The methodology translates Leonardi's logic of selective observation into a reproducible digital workflow, integrating current 3D scanning technologies and XR. The process follows three distinct phases: Data Acquisition (Scanning), Processing (Abstracting), and Deployment (Augmenting).

### 3.1 Data Acquisition: Scanning

The case study focuses on a mature *Platanus* × *acerifolia* located at the Karlsruhe Institute of Technology (49°00'38.3"N 8°24'40.2"E), selected for its structural integrity and lack of pruning. The scan yields a raw point cloud of roughly 17 million points, preserving geometric detail while retaining sensor's limitations such as occlusions by dense foliage and branches or noise in shadowed or reflecting areas. Rather than cleaning the data to produce a simplified mesh, these artifacts are preserved as the inherent texture of the digital scan (Fig. 2).

### 3.2 Processing Strategy: Abstraction

Instead of reconstructing the missing geometry with synthetic geometry (LEE et al. 2025, YAO & FRICKER 2024) we preserve the point cloud with minimum processing. To avoid the technocratic solutionism of hyper-realistic rendering, the visualization strategy follows a strict reductionist protocol. Where Leonardi reduced a tree's complex variables to two spatial dimensions (*x, y*) and a binary (i. e., monochrome) ink value, TS$^{AR}$ operates in three dimensions (*x, y, z*) but reduces the color variable (*R, G, B*) to a uniform black (0, 0, 0). This removes the reliance on photorealism. The resulting visual output relies entirely on granulometry, i. e. the density of points per cubic meter, to convey volume and opacity. This ensures the digital twin functions as a structural diagram rather than a cosmetic replica.

**Fig. 2:** Elevation of the scanned digital surrogate of the *Platanus* × *acerifolia* located at the Karlsruhe Institute of Technology (49°00’38.3”N 8°24’40.2”E) (Image Credit: the authors)

## 3.3 Deployment and User Interface (UI): Augmenting

To address the need for accessibility without specialized hardware (e. g., Virtual Reality headsets), the point cloud was optimized for WebAR (Web-based Augmented Reality) using the AR Code platform. The file was downsampled to <10MB using an octree compression structure to ensure low-latency loading on standard smartphones (iOS and Android) and accessibility via standard web browser.

**Field Setup:** The experience was anchored to a fixed geographic position at Festplatz in Karlsruhe (49°00’11.3”N 8°24’09.7”E) during the *Media art is here* festival. Through the festival 430 participants scanned the QR code and actively interacted and navigated the 1:1 scale digital entity (Fig. 3) in situ.

**User Experience (UX):** Addressing the interface design, $TS^{AR}$ adopts a minimalistic interface approach. Upon scanning the QR code, the user sees only the camera feed and the superimposed point cloud. There are no menus, botanical labels, or data overlays. This absence of interface clutter is a methodological choice to force a direct, phenomenological encounter. The user’s role shifts from reading data to navigating space, i. e. walking around and through the point cloud to comprehend its structure (Fig. 4).

**Fig. 3:** One person using a cellphone at Festplatz, Karlsruhe to visualize the AR model of the *Platanus* × *acerifolia* during the *Media art is here* festival (Image Credit: Felix Grünschloß)


**Fig. 4:** AR navigation around the model of the *Platanus* × *acerifolia* during the *Media art is here* festival at Festplatz, Karlsruhe, as seen in a cellphone (Image Credit: the authors)

# 4 Discussion: Progress and Uniqueness

Merging well-known point cloud technology with the methodological principles of "The Architecture of Trees" provides a unique framework to explore the phenomenology of TS$^{AR}$ and its implementation in landscape architecture practice.

## 4.1 TS$^{AR}$ as a Critique to Representation

This project extends, and reinterpret, Leonardi's paper-based static 2D analytical drawings into a 4D phygital experience (3D space + time/interaction). Unlike a drawing, the point

cloud reveals volumetric complexity, parallax, and spatial immersion, which allows users to inhabit the tree's form rather than simply viewing it. This shift moves beyond documentation toward embodied perception, enabling human cognition and interaction: representation becomes experience. As Leonardi's drawings, $TS^{AR}$ requires attentive and prolonged observation, there is more to see than forms: time, growth, exception and particularities are revealed to the exhaustive viewer.

The project uniqueness lies in its critical position towards digital aesthetics. It avoids hyperreal rendering, or exuberant formalism of common consumer AR applications. Instead, it embraces the point cloud's inherent abstraction, becoming a curated sampling of a living entity. This results into a simultaneous feeling of metric accuracy (and so, realism), and artificial fragmentation, a tension that highlights the mediated nature of all representation, challenging traditional landscape architecture documentation methods.

## 4.2 $TS^{AR}$ as a Mediated Encounter

Digital technologies promise inexhaustible detail. Yet abundance can be anaesthetic. The precision of millions of points may overwhelm the perceptual economy that makes drawing intelligible. While Leonardi's minimal line encoded essential proportions; the point cloud risks dissolving meaning in numerical excess. $TS^{AR}$ therefore experiments with reduction: decimated datasets, single point size, and false-monocolor generate alternative "aesthetic regimes" (RANCIÈRE 2000) of digital botany. These acts of restraint recall the selective framing of analogue representation and resist the contemporary fetish for hyperreal visualization that dominates architectural imagery.

This position aligns with critiques of hyper-technological aesthetics and techno-spectacle in design culture (DEBORD 1967). By enforcing aesthetic scarcity within digital abundance, the project resists the uncritical valorization of photorealistic rendering and excessive computational complexity. Such visual regimes often mask sensory hyper-saturation (BAUDRILLARD 1981), capturing attention and eroding contemplation (HAN 2010). In contrast, the project privileges ambiguity, allowing perception rather than data to complete form, becoming an ontological threshold where traditional categories (object, space, surface, boundary) lose rigidity and become renegotiated in phenomenological experience. This mediation is made evident, visible and adjustable, affecting the three stages of understanding (KIRK 2016): perceiving, interpreting and comprehending. The impact on the last phase implies that the digital twin becomes a medium and a territory for design speculation.

## 4.3 $TS^{AR}$ as a Design Enabler

The *Media art is here* festival participants are not designers or people with particularly strong digital competences, just Karlsruhe citizens and visitors, interested in interacting with the proposal. User feedback was informally collected during several moments of the festival, highlighting the application's immediate accessibility and ease of use, as well as the intuitive legibility of the augmented tree representation. The chosen graphic abstraction was perceived as particularly effective in leaving interpretative space, thereby enabling users to imagine alternative spatial configurations involving the implanted tree.

This project is not a final representation, but the generation of a world in which design thinking takes place. De Landa distinguishes between the actual (i. e. a property, like a tree's current state) and the virtual (i. e. its capacities and tendencies, what it can do). The virtual

is “fully real” as a structure of possibilities (DELANDA 2015). In our case, the actual is the specific, imperfect point cloud dataset that was captured. The virtual is the structure of possibilities that this data implies. The gaps and variations in the point cloud don’t just represent “missing data”; they represent the tree’s capacity to grow, change, sway in the wind, lose leaves, and be seen from different angles. They are a digital record of the tree’s degrees of freedom.

A perfect model would kill the virtual; it presents the tree as a finished, actualized object. An imperfect point cloud, however, preserves the virtual. It is a representation that acknowledges what the tree is but also hints at everything it could become. It is a “structure of a possibility space” for the tree’s future growth and interaction.

This approach questions also authenticity, as it is a digital surrogate that omits roots, soil, scent, sound, and even biological and energy flows. As cities increasingly adopt twins for planning, it is important to pinpoint that fidelity is not the same as truth. A scan may capture geometry, but it cannot convey ecological relationships without deliberate curation.

TS$^{AR}$ is not only valuable for urban nature planners but also reframes participation through relational design. While AR, and more broadly XR, are often used to increase citizens’ engagement and participation on design proposals (AHMADI OLOONABADI & BARAN 2023), we propose here that meaningful participation starts with perception. Before people can co-design with digital tools, they must first develop a shared, affective relationship. This positions XR not as a mere consultation interface, but as pedagogical medium and ecological literacy connected to more-than-human care.

# 5 Conclusion

TS$^{AR}$ continues Leonardi’s legacy not by replicating his methods, but by translating his core question of how we can see trees as integral to architecture into the digital present. It speculates that the future of digital representation in landscape architecture depends not only on ever- higher fidelity, but on thoughtful curated mediation. It means choosing what to show, what to omit, and how to frame the encounter.

By translating Leonardi and Stagi’s reductionist graphics into a spatial experience, TS$^{AR}$ shows that a minimalistic AR installation stripping away hyper-realistic textures and visualization from digital abundance paradoxically can amplify phenomenological engagement with urban nature. Removing explicit UI elements and the direct immersive overlay of the sole point cloud as a primary aesthetic invites the viewer to actively navigate through a physical encounter shifting the participant’s focus from the device to the organism.

Critically, TS$^{AR}$ positions XR as a counter-narrative to the prevailing logic of Urban Digital Twins, where the latter reduce vegetation to computable entities for simulation efficiency. Hence, TSAR shifts the role of the digital model from an instrument of quantification to an instrument of qualification, that privileges organic singularity over algorithmic precision.

Ultimately, TS$^{AR}$ reframes the landscape architect’s role from designing static planting schemes to curating phygital encounters, using the point cloud not as a data product but as a pedagogical medium for ecological literacy and reflection. Therefore, it is possible to think about digital tools that can do more than optimize or simulate: they can re-enchant, in the sense of cognitive and affective engagement, without overexciting and calling for attention.

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