

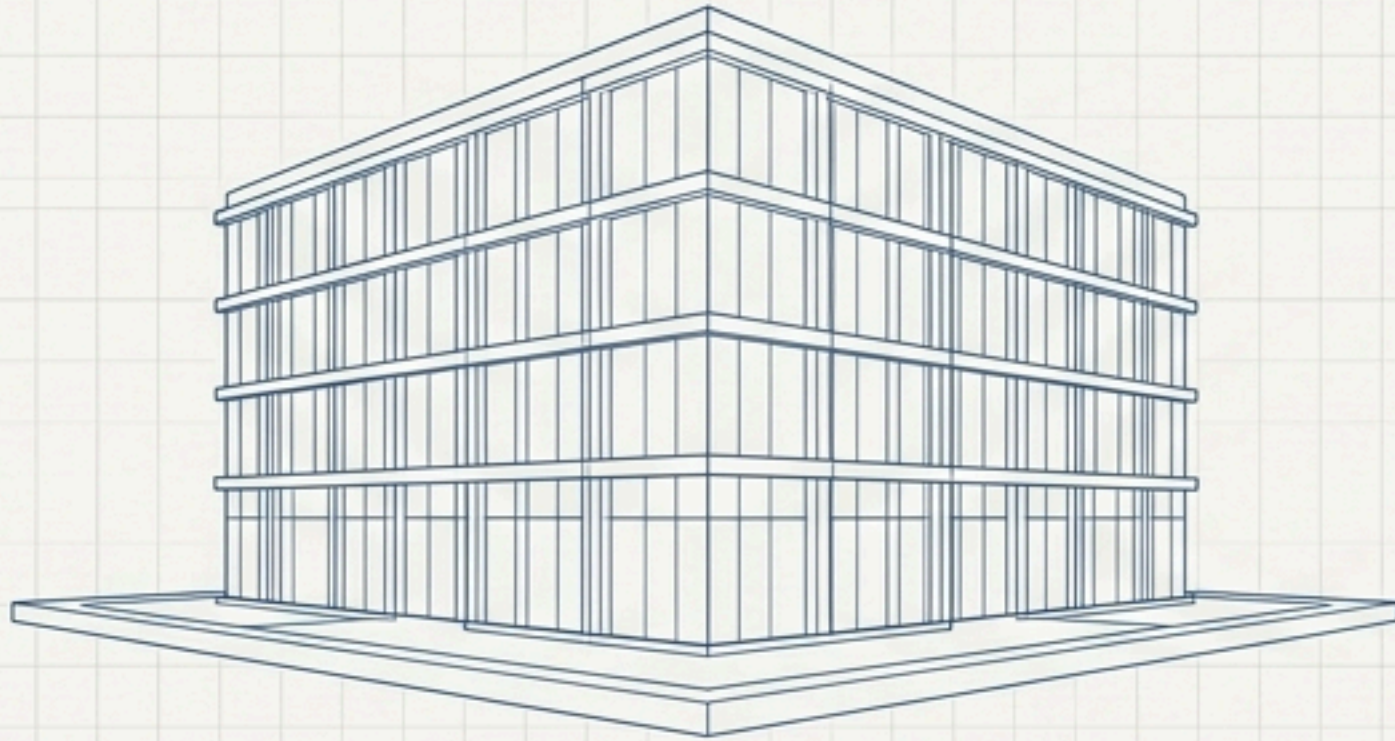
Scan-to-BIM for Heritage Structures

From Point Clouds to
Parametric Intelligence



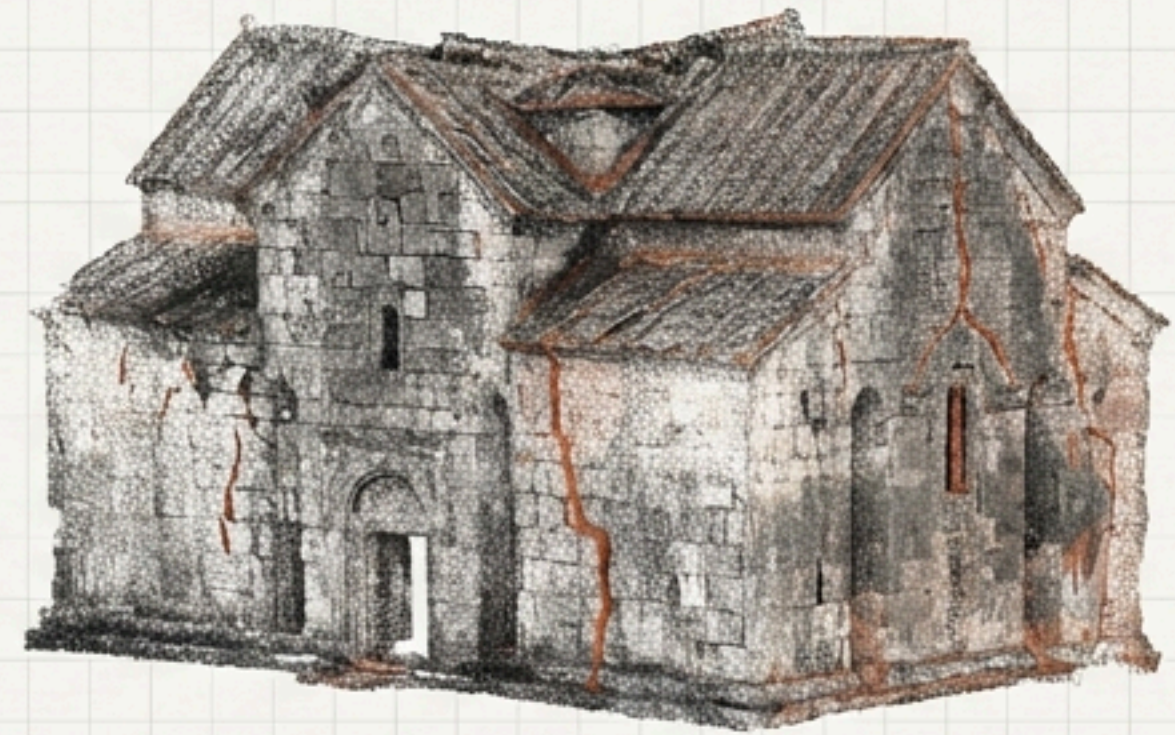
THE HERITAGE MODELING PARADOX

MODERN CONSTRUCTION LOGIC



- STRAIGHT WALLS
- STANDARDIZED WINDOWS
- PERFECT SYMMETRY
- PREDICTABLE MATERIAL BEHAVIOR

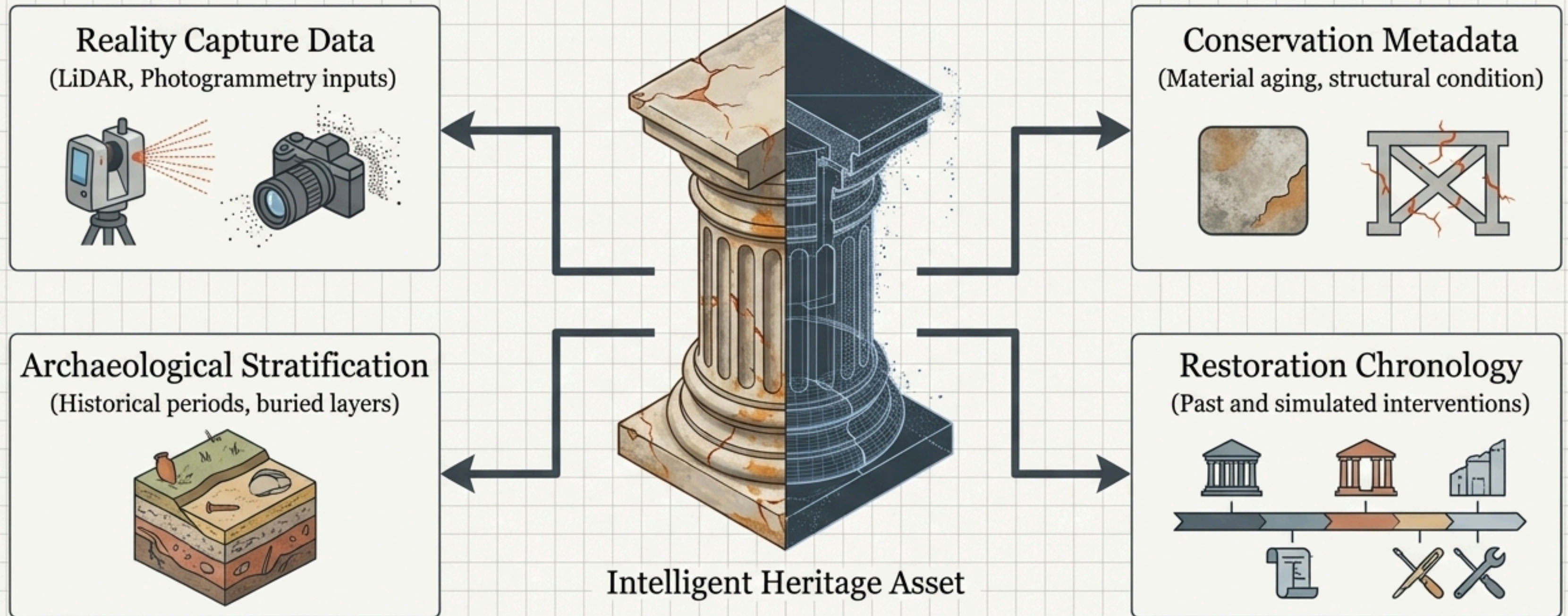
HERITAGE REALITY



- WARPED VAULTS
- UNEVEN MASONRY & ORGANIC DEFORMATION
- UNDOCUMENTED HISTORICAL MODIFICATIONS
- HANDCRAFTED ASYMMETRY

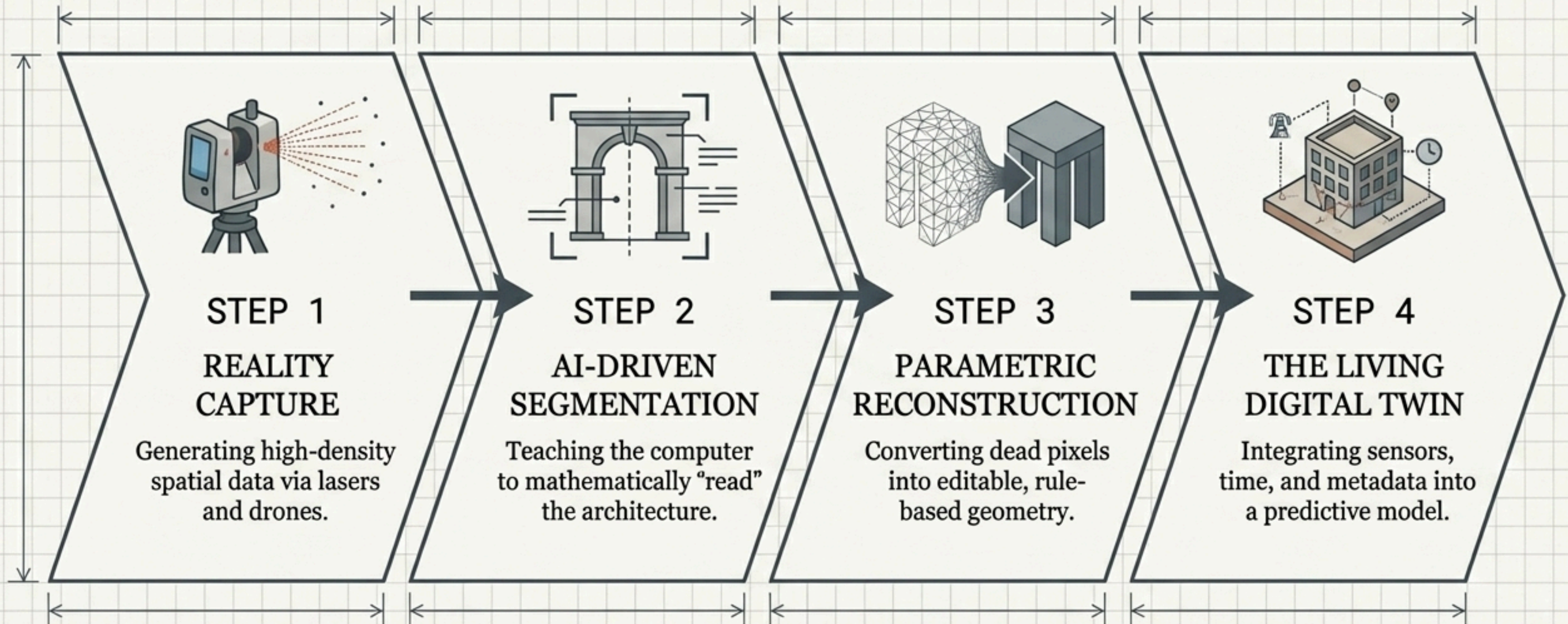
CORE TAKEAWAY: TRADITIONAL BIM PLATFORMS ARE OPTIMIZED FOR STANDARD GEOMETRY. HERITAGE STRUCTURES DEMAND A FRAMEWORK CAPABLE OF COMPUTATIONALLY INTERPRETING NON-LINEAR REALITY.

Historic Building Information Modeling (HBIM)

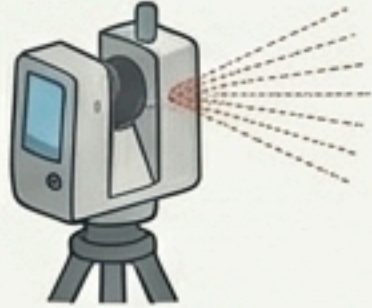


Core Takeaway: HBIM adapts modern BIM workflows to represent complex, non-standard historical forms layered with centuries of conservation data.

THE COMPUTATIONAL TRANSFORMATION PIPELINE



Step 1: Reality Capture Geometries



Terrestrial LiDAR (TLS)

Strength: High geometric accuracy.
Optimal for: Base structures and primary load-bearing walls.



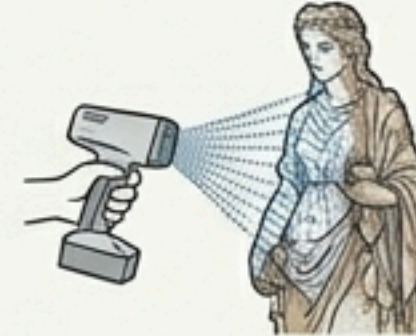
Drone Photogrammetry (UAV)

Strength: Aerial spatial capture.
Optimal for: Roofs, spires, and inaccessible facades.



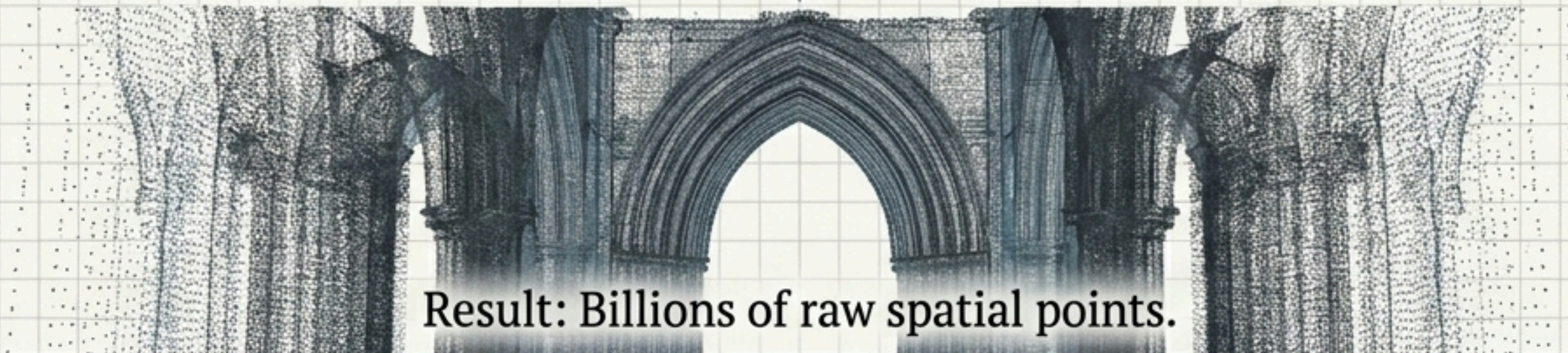
SLAM Scanning

Strength: Mobile tracking.
Optimal for: Rapid mapping of complex, winding interior corridors.



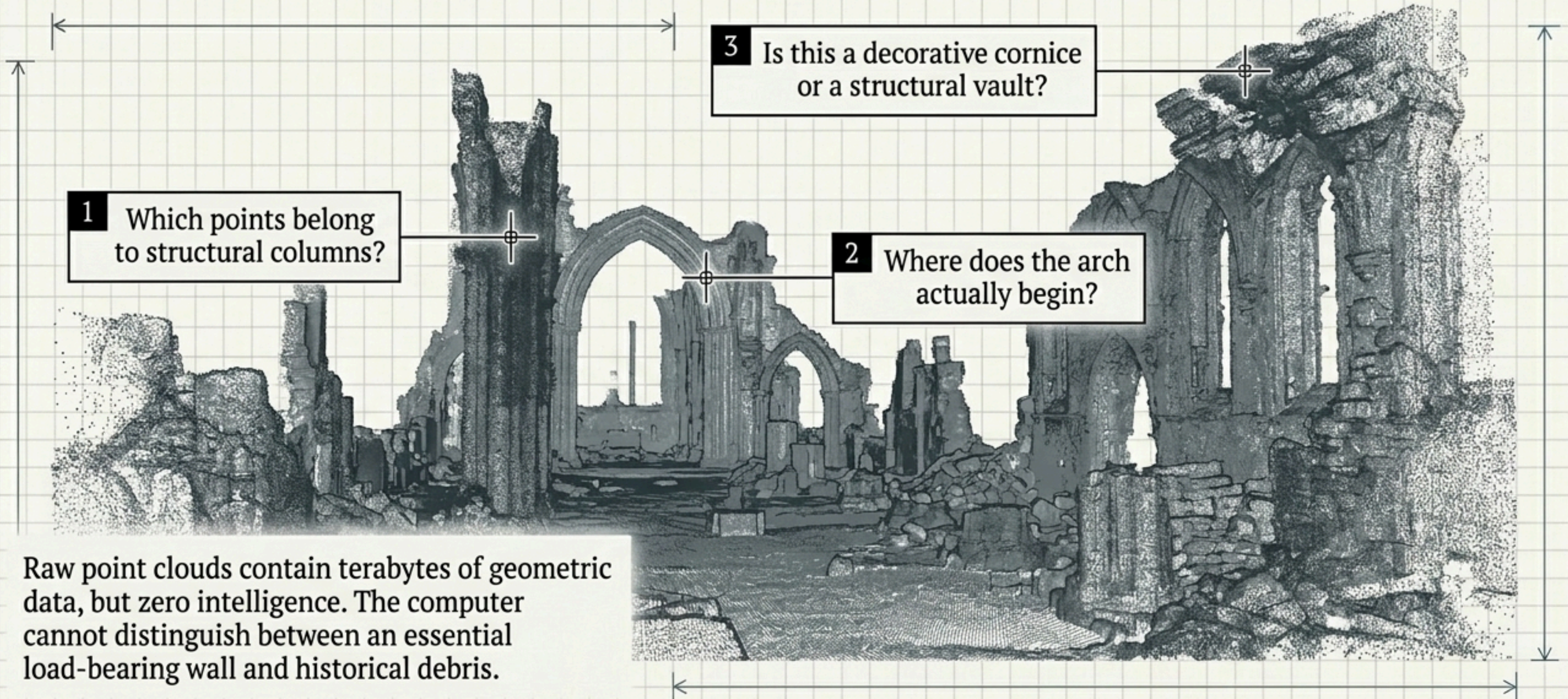
Structured Light

Strength: Micron-level detail.
Optimal for: Fine ornamentation, statues, and eroded carvings.



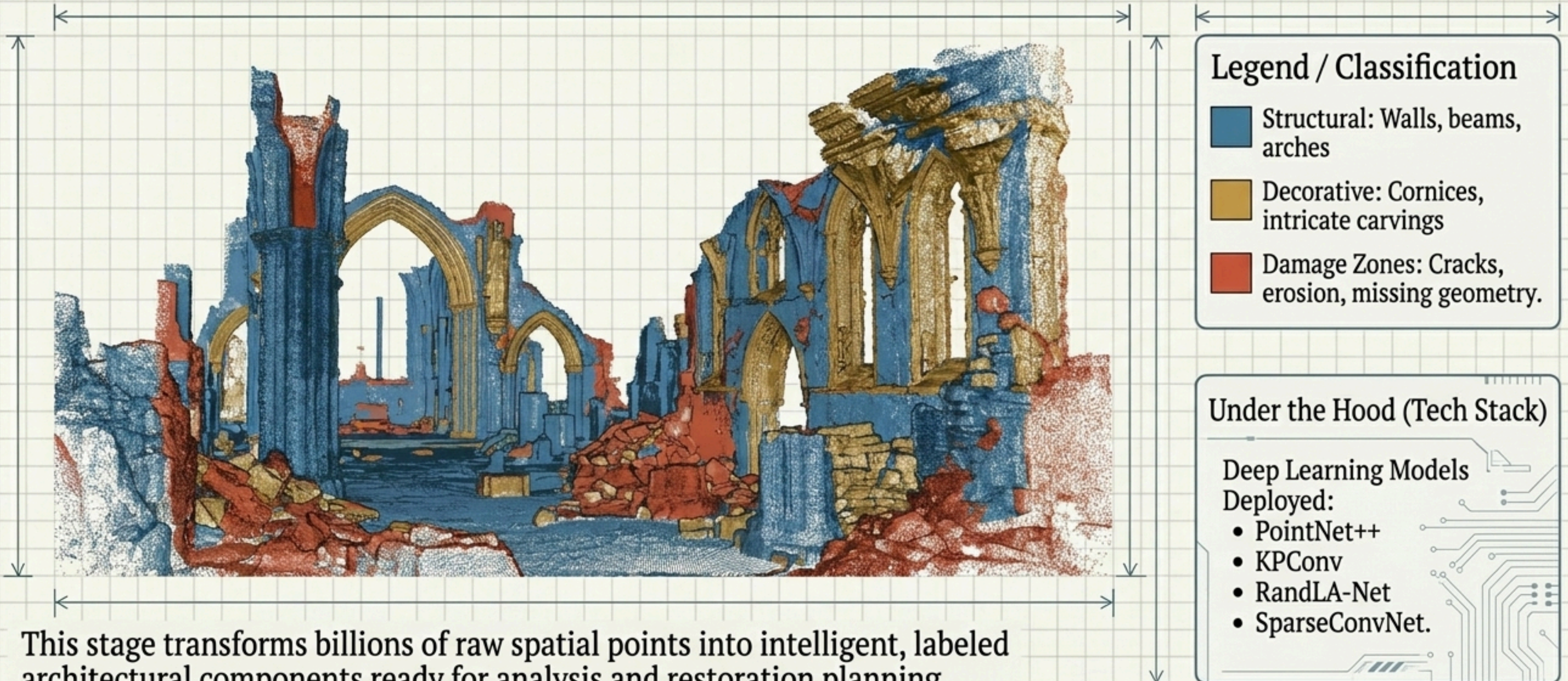
Result: Billions of raw spatial points.

THE POINT CLOUD BOTTLENECK



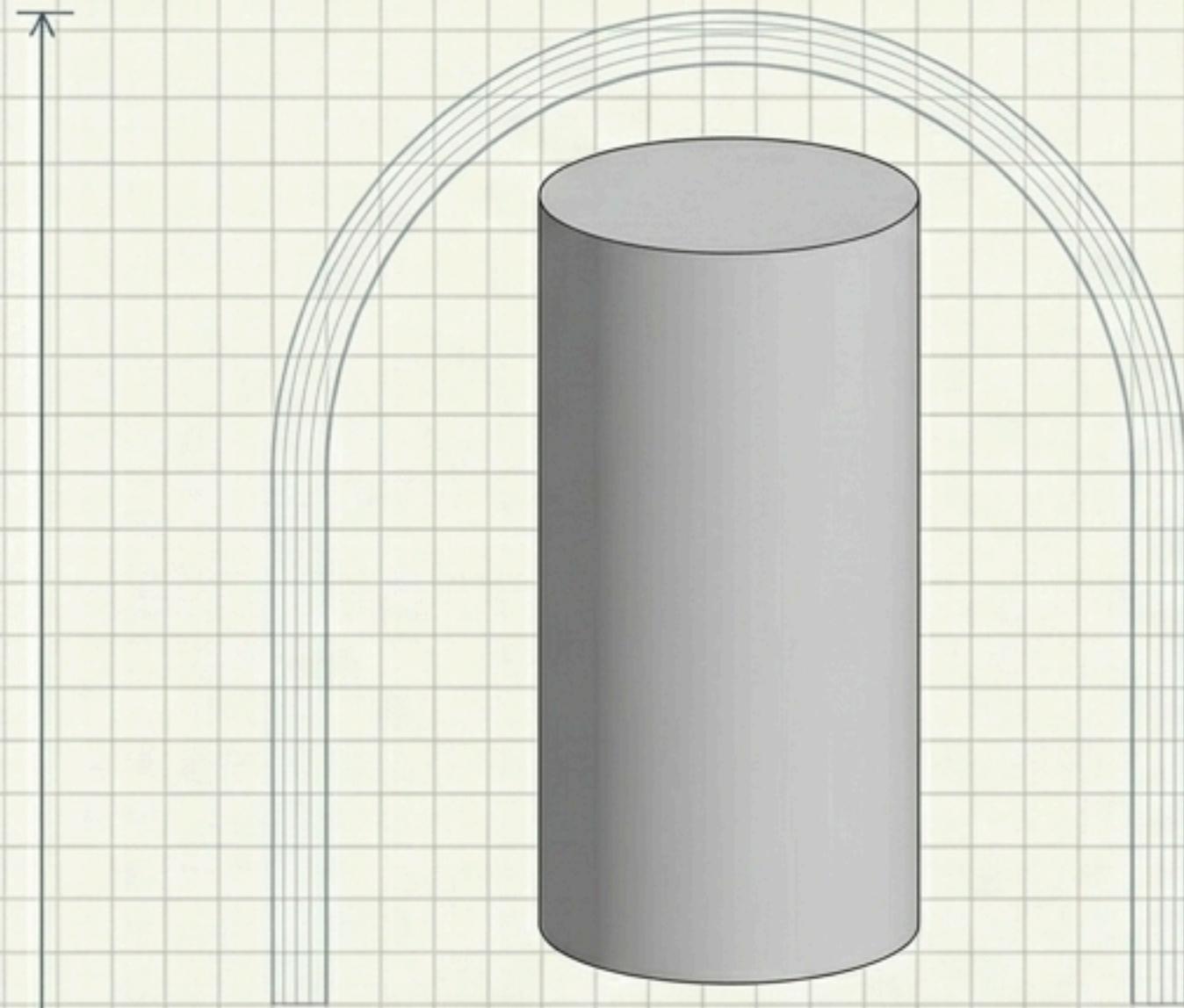
Step 2: Semantic AI Segmentation

AI provides context-aware recognition, learning features directly from irregular, handcrafted geometries.



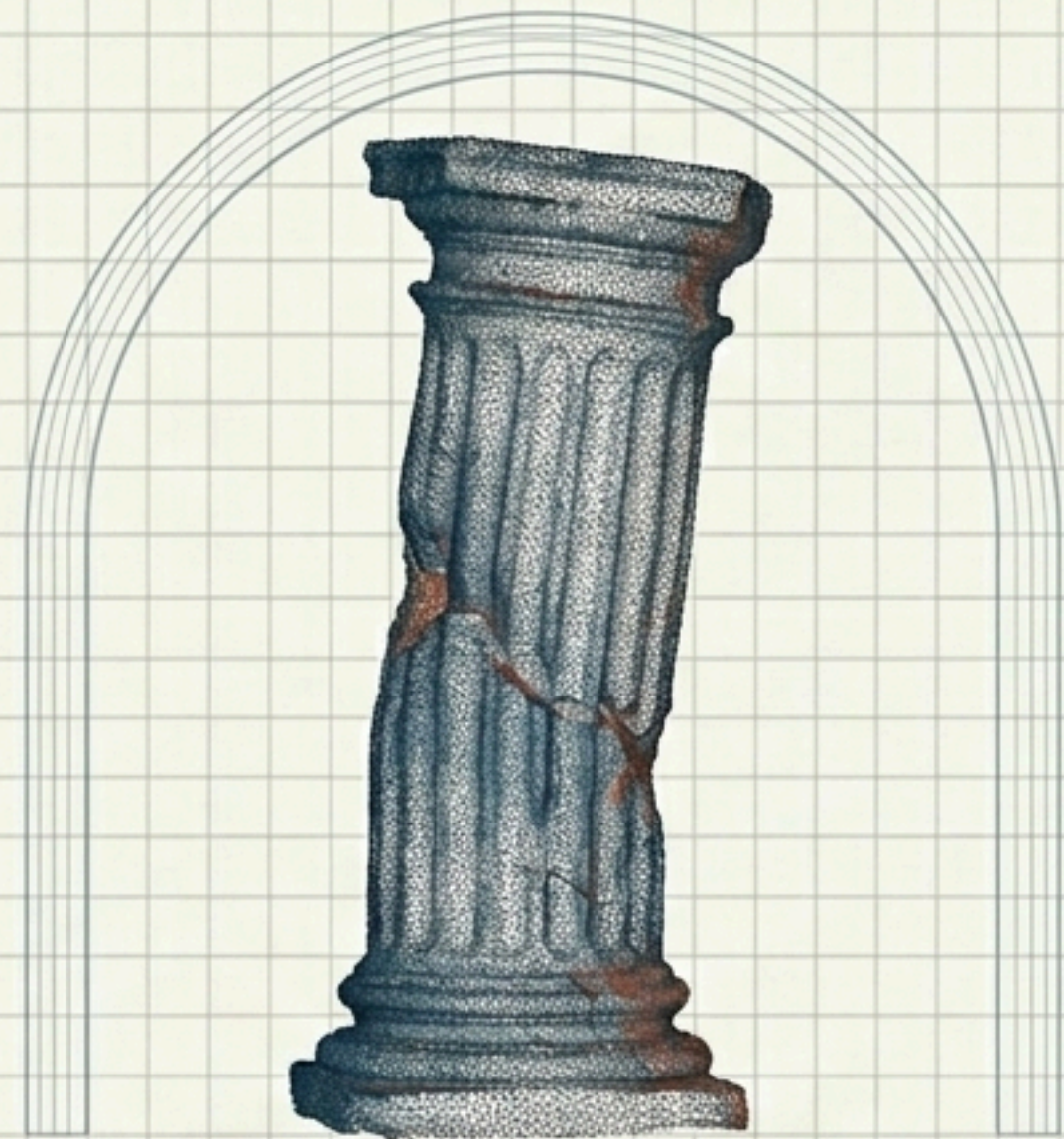
The Parametric Modeling Challenge

How do we convert segmented points into editable BIM objects? Modern software wants static, standardized shapes. Heritage requires geometric flexibility that honors centuries of physical alteration.



Standard BIM

Idealized Orthogonal Geometry.



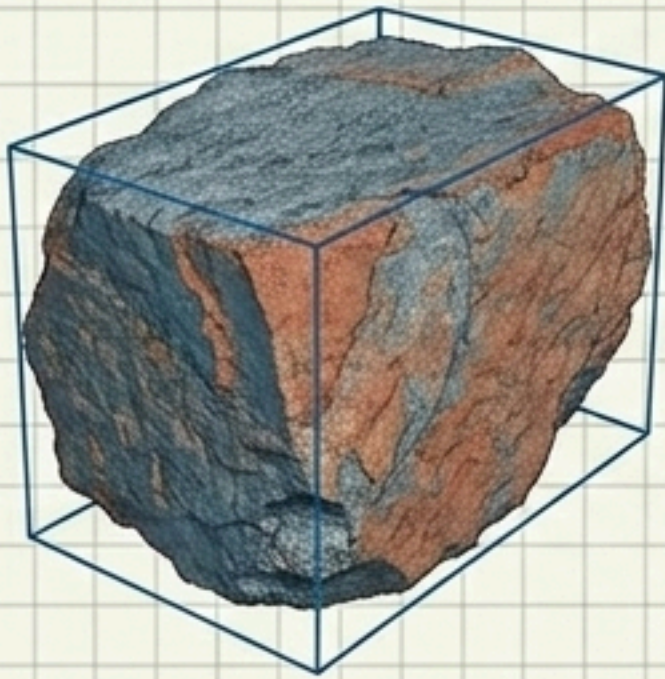
HBIM Reality

Handcrafted Historical Irregularity.

Step 3: Reconstruction Approaches

A progressive spectrum capabilities to devake computational reconstruction techniquistes.

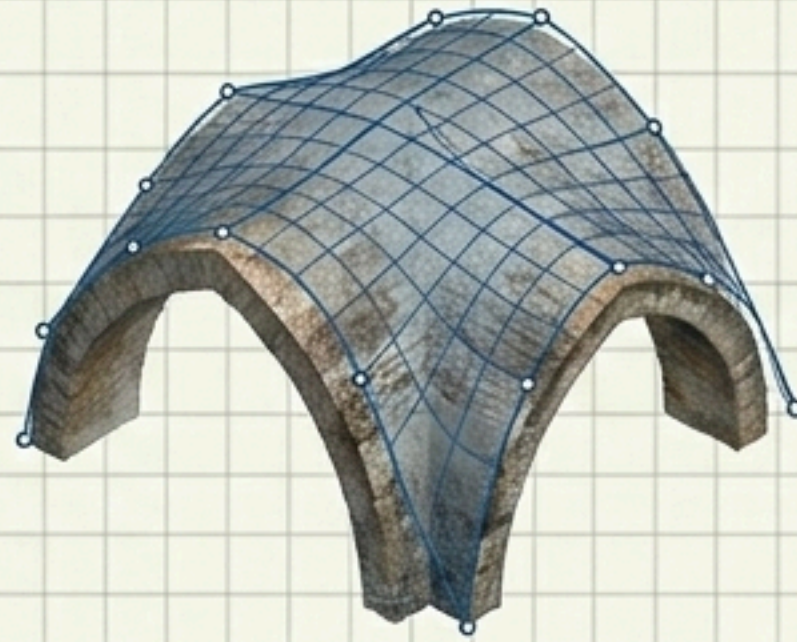
Primitive-Based



Fast, BIM-compatible fitting (perfect cylinders/planes).

Limitation: Oversimplifies heritage complexity.

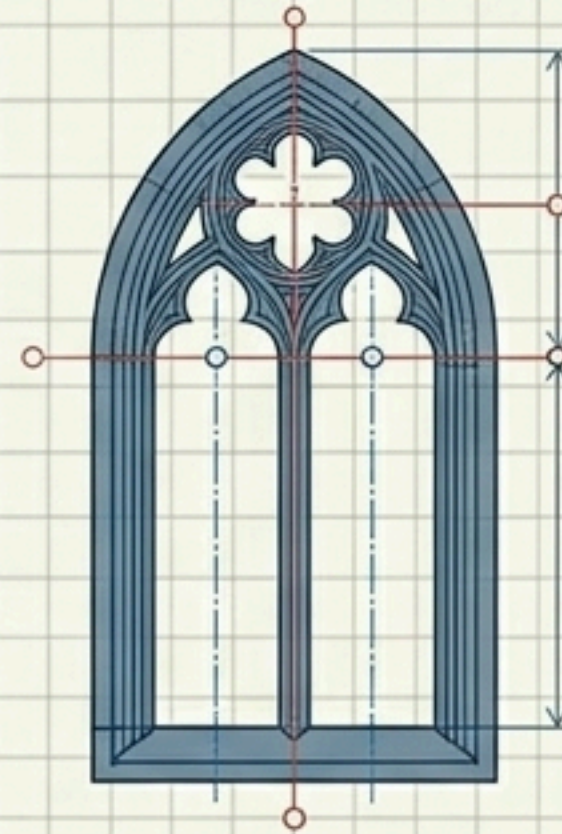
NURBS Surfaces



Smooth mathematical representation of curved masonry.

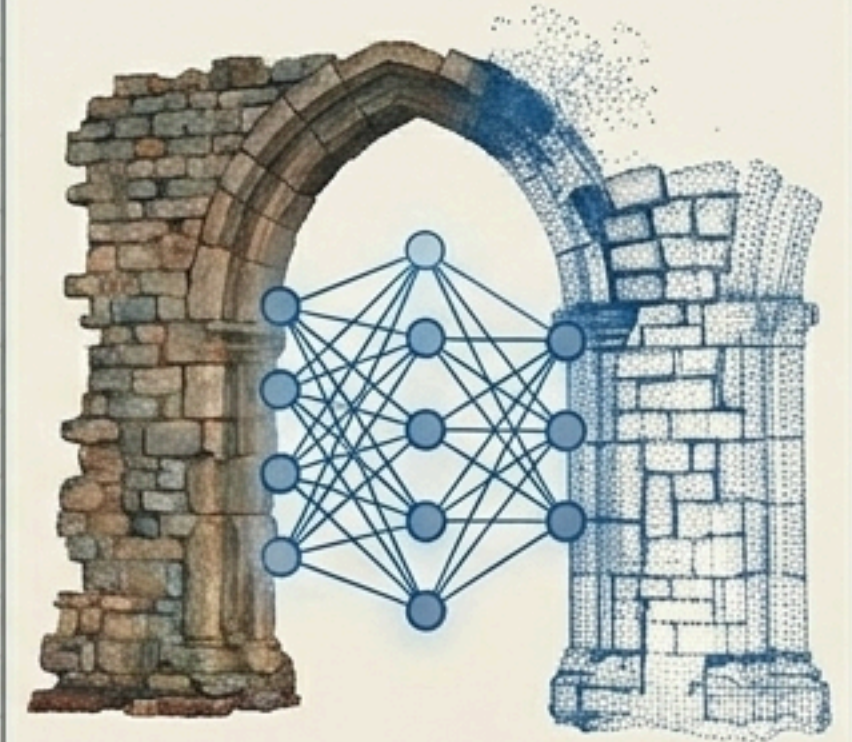
Limitation: High manual modeling intervention required.

Procedural / Rule-Based



Encodes architectural grammar and symmetry constraints for scalable reconstruction

AI-Driven Modeling



Generative AI and neural implicit surfaces.

Capability: Infers missing geometry, predicts symmetry, and automates BIM family generation

Step 4: The Living Digital Twin

5. Analytics
Risk prediction &
stress modeling

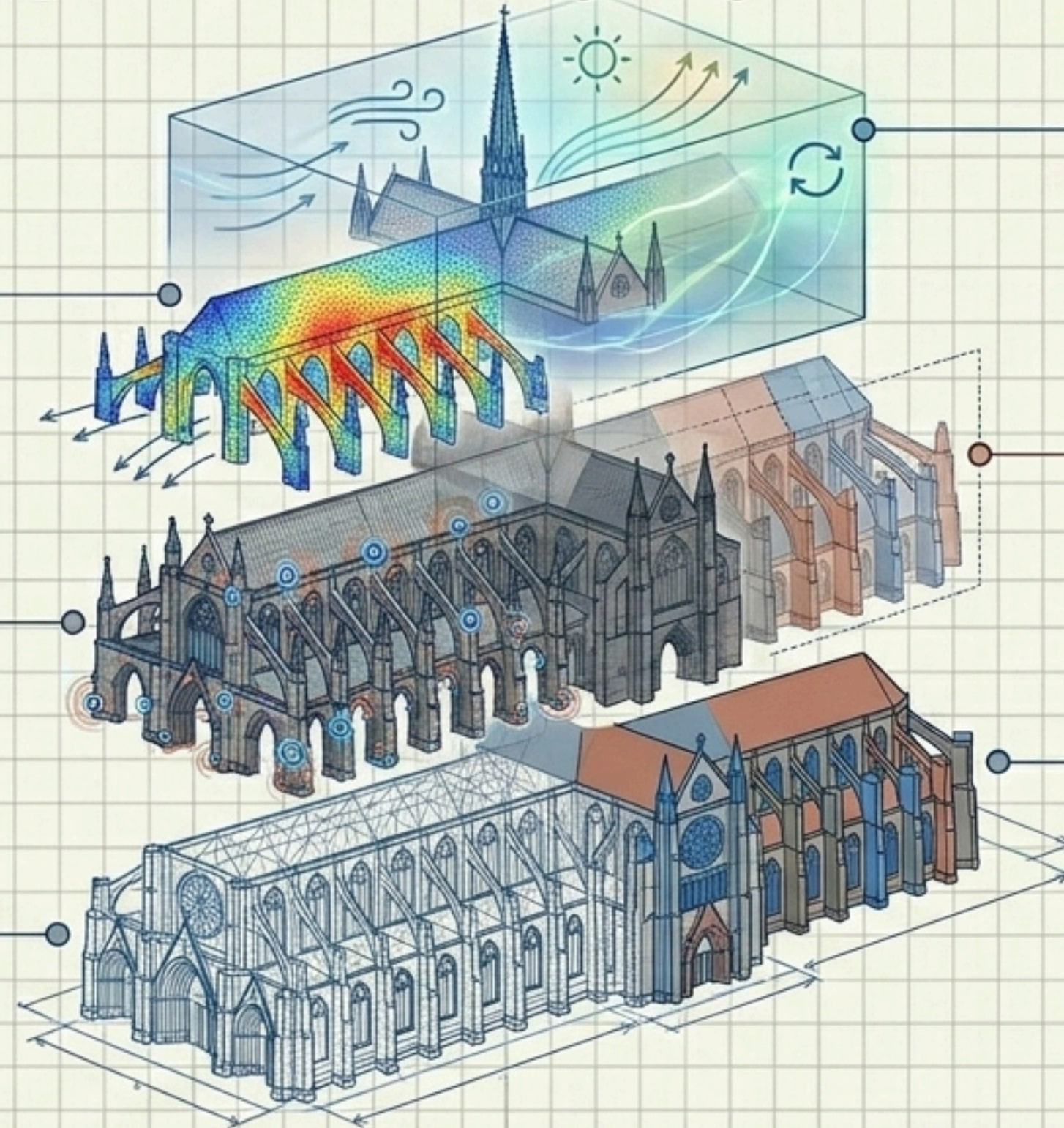
6. Sustainability
Energy and lifecycle
analysis

4. Time
Restoration chronology
& simulation

2. Semantics
Architectural intelligence
& labeled objects

3. Sensors
Structural health
monitoring IoT

1. Geometry
Accurate spatial
representation



Core Takeaway: Transforming heritage management from reactive preservation to predictive conservation.



Active Conservation Intelligence



Cathedral Documentation



Application: Seismic assessment and structural crack monitoring.

Archaeological Reconstruction



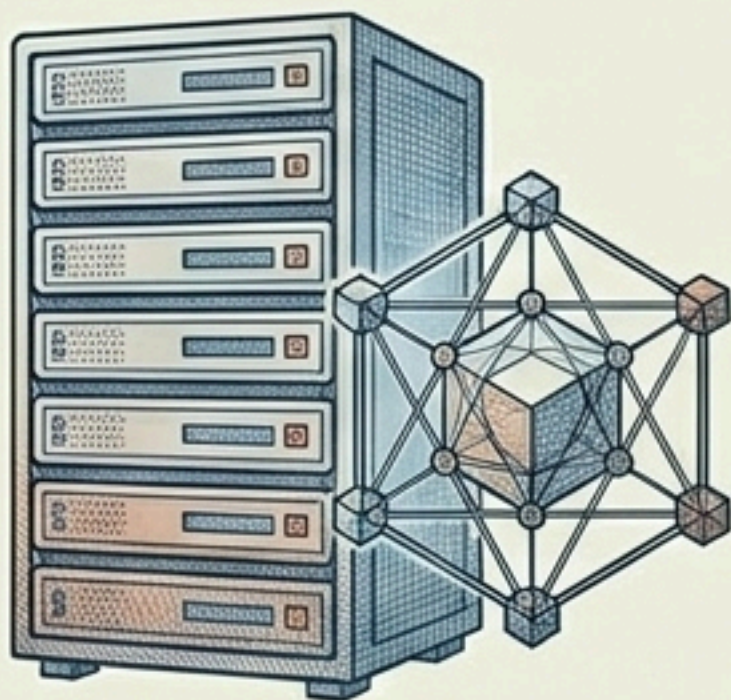
Application: AI-assisted recreation of fragmented monuments and ancient settlements.

Restoration Planning



Application: Simulating interventions, comparing historical phases, and tracking material decay over time.

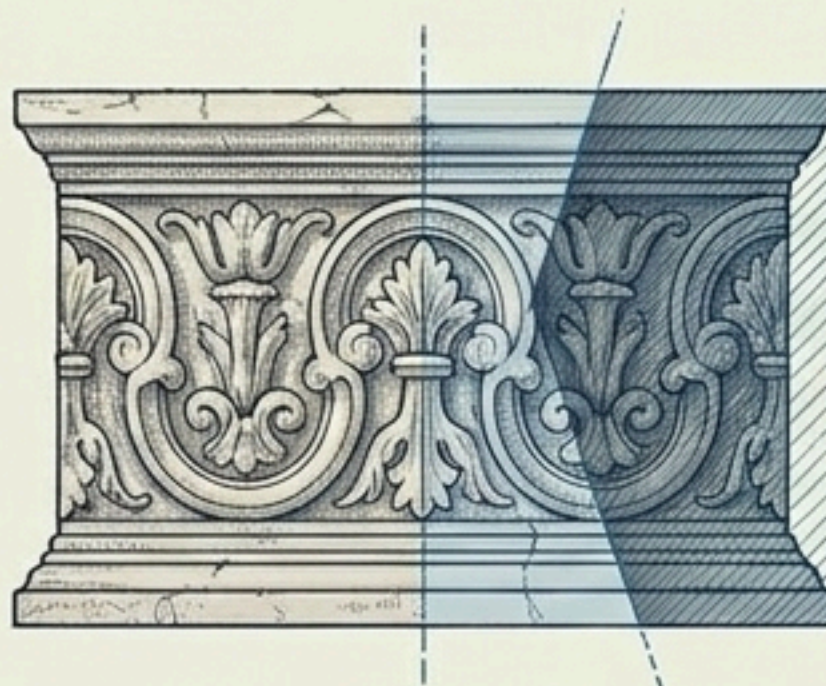
Current Technical Bottlenecks



Data Scale

Reality: Heritage scans easily exceed terabytes.

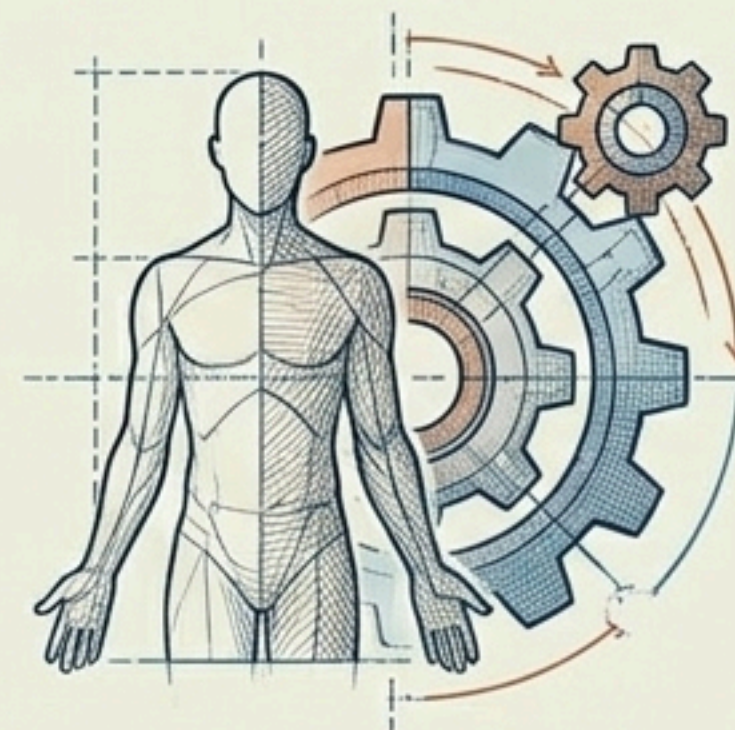
Requirement: **Spatial indexing**, octree optimization, and heavy GPU acceleration.



Occlusion Zones

Reality: Dense historical ornamentation creates hidden 'blind' regions.

Solutions: **Multi-scan registration**, drone integration, and AI-based geometric completion.



The Automation Gap

Reality: Fully automatic **Scan-to-HBIM** remains an open research problem.

Solution: **Human expertise** remains irreplaceable for historical interpretation and conservation decisions.



The Emerging Tech Horizon

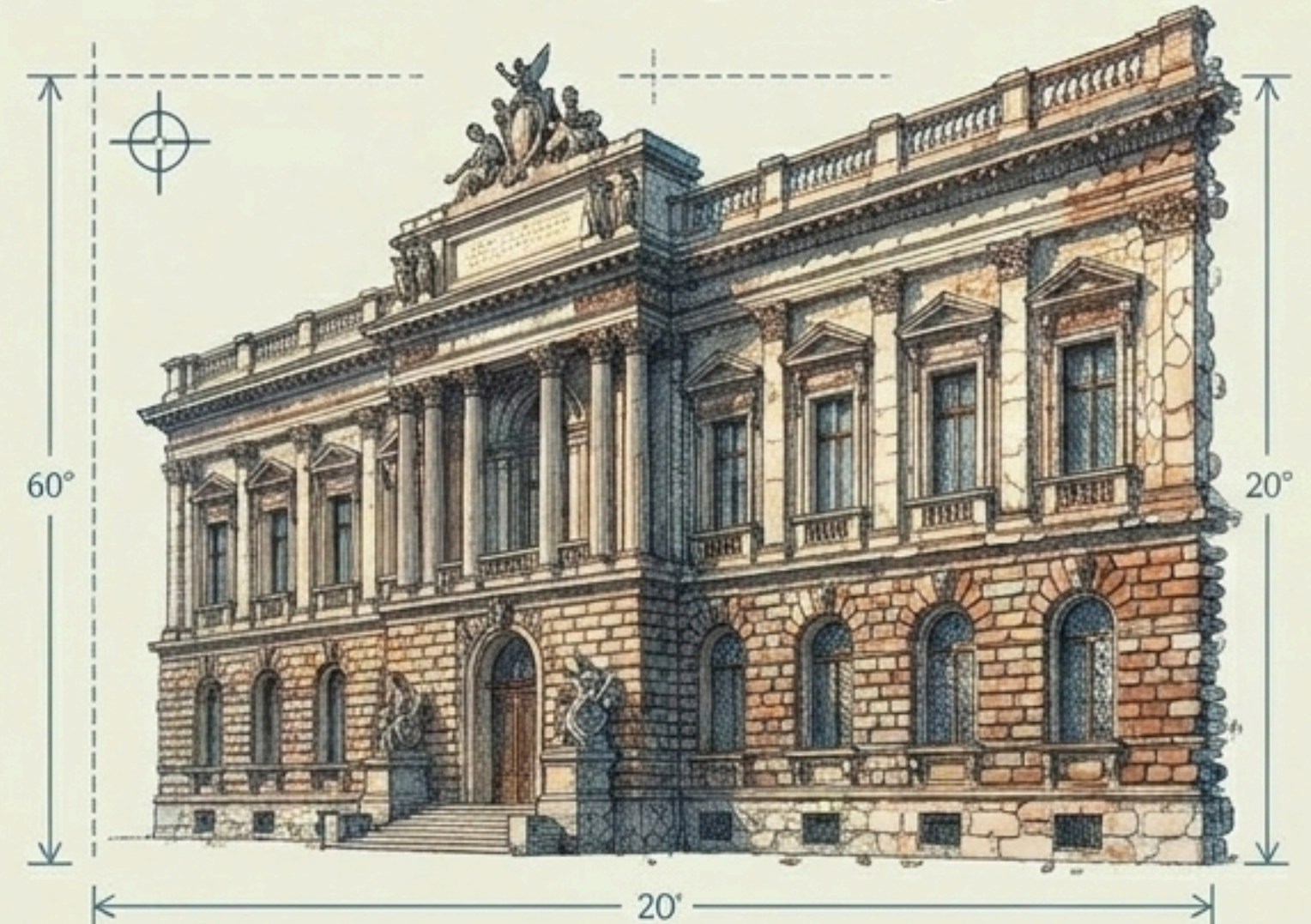


Neural Radiance Fields (NeRFs)



Synthesizing novel views from 2D images for immersive AR/VR restoration workflows.

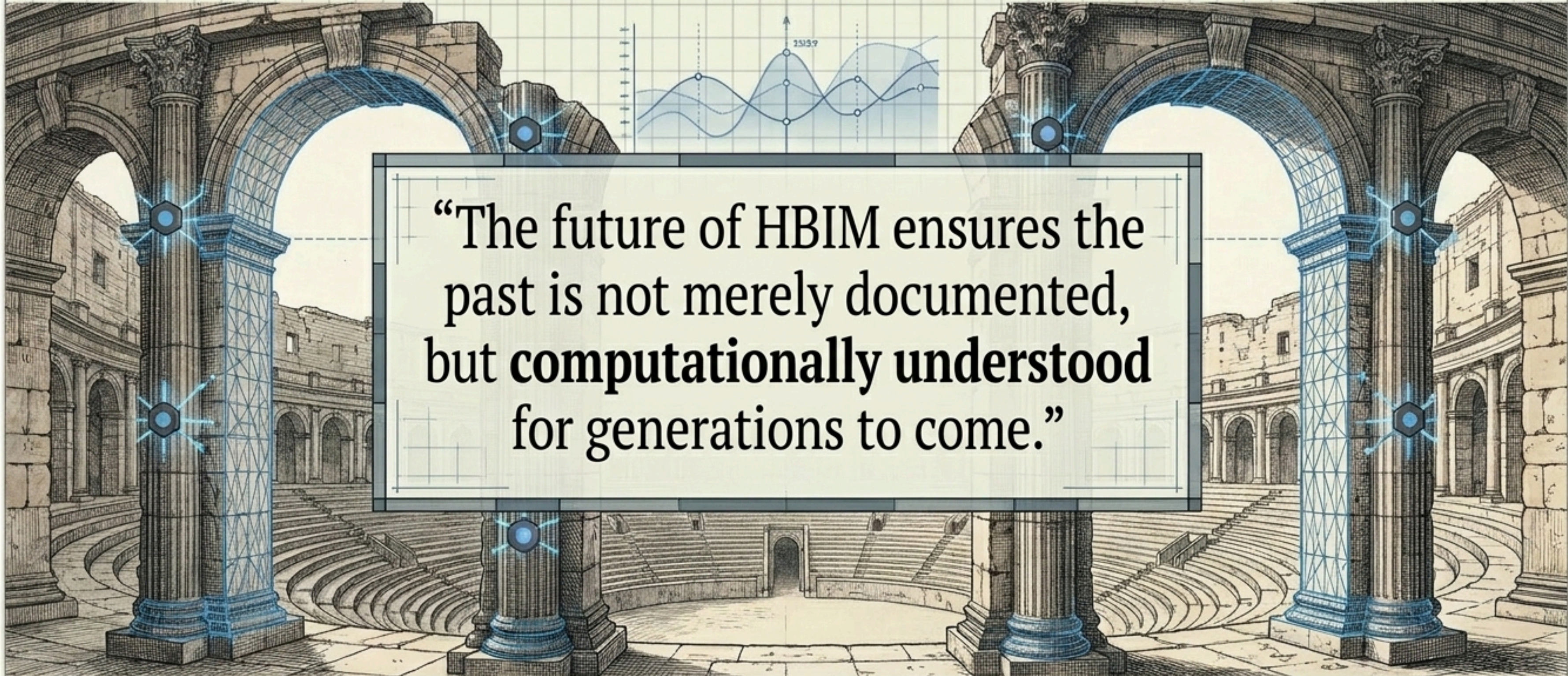
Gaussian Splatting



Real-time rendering of exceptionally complex heritage scans for web-based digital heritage and museum platforms.



Computationally Understanding the Past



“The future of HBIM ensures the past is not merely documented, but **computationally understood** for generations to come.”

As AI, computational geometry, and digital twin technologies evolve, heritage structures transform into continuously monitored intelligent assets.

Preserve History with Intelligent HBIM Solutions

Bring centuries-old architecture into the future with precision-driven Scan-to-BIM workflows.

Capabilities

- Precision reality capture (LiDAR & UAV)
- AI-driven point cloud segmentation
- Parametric reconstruction of complex geometries
- Heritage digital twin development



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