

FROM REAL TO VIRTUAL

Engineering an Interactive 3D Human Body
from Real Human Cadaver DICOM Data



Real Human
Cadaver Data



DICOM
Imaging



Advanced 3D
Reconstruction



Interactive 3D
Anatomy

CADAVIZ

REAL DATA. REAL ANATOMY. REAL IMPACT.



POPULATION DIVERSE
ANATOMY LIBRARY



MEDICAL EDUCATION
AND TRAINING



ANATOMICAL RESEARCH
AND INNOVATION



CLINICAL CORRELATION
AND SURGICAL PLANNING



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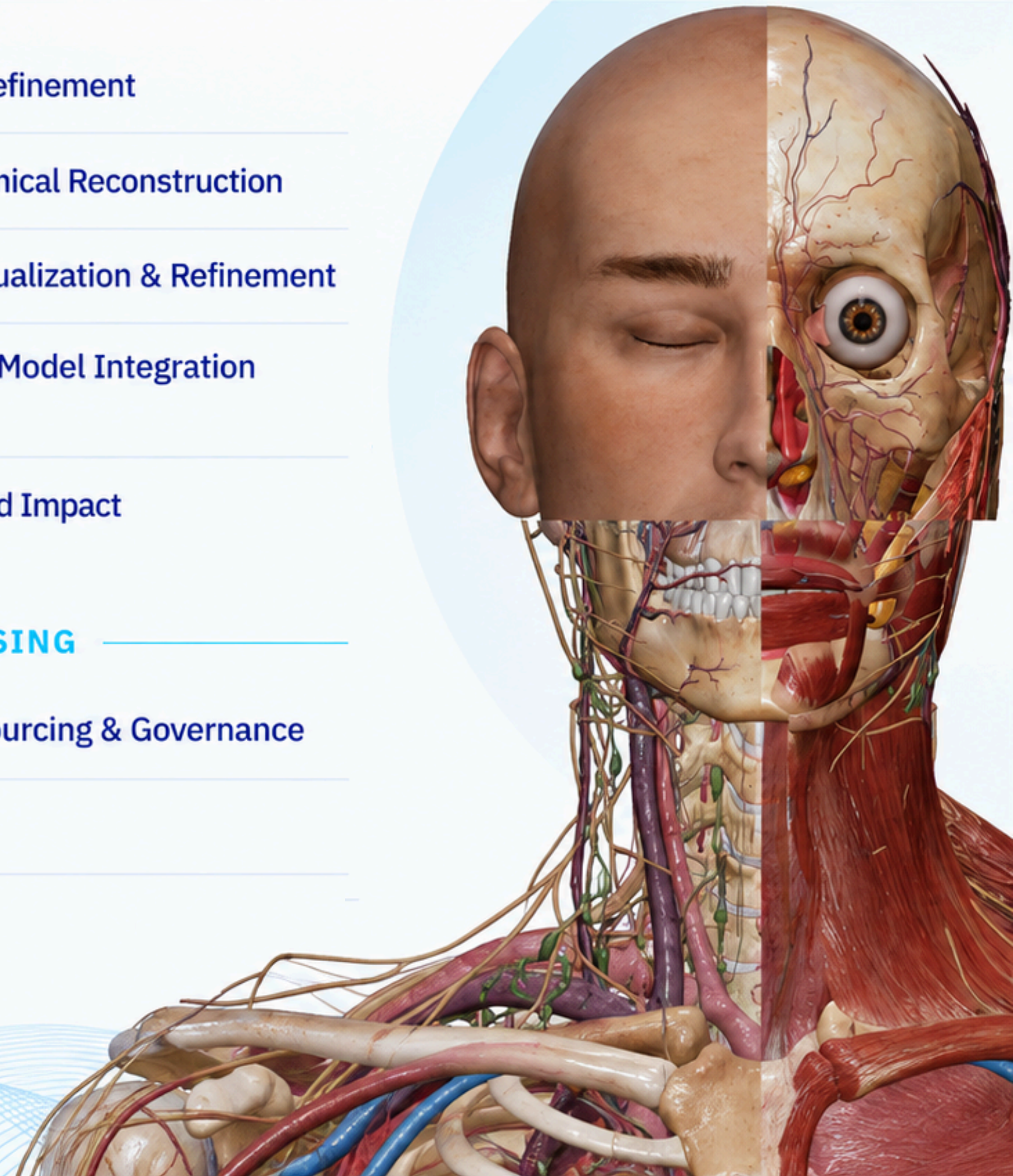
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Executive Summary



From limited datasets to a broader reality

- Most reference anatomy resources, from classical atlases to digital 3D anatomy platforms, are built from datasets representing limited populations.
- Human anatomy varies across individuals and populations, so a single reference model may not fully represent the anatomical diversity encountered in clinical practice.
- For medical education and training, incorporating anatomically diverse, real-world imaging data can therefore provide a broader and more representative understanding of human anatomy.



Turning real-world data into immersive learning

- This white paper describes how CADAVID addresses this gap by incorporating ethically sourced, real-world DICOM data through institutional collaborations and transforming these datasets through a defined real-to-virtual pipeline into interactive 3D anatomical models.
- By moving from standardized reference anatomy toward data-driven, population-diverse and patient-specific 3D anatomy, CADAVID provides a scalable framework with potential applications in medical education, anatomical research, clinical correlation, and surgical planning across global healthcare and education settings.

Problem Statement

DIVERSE ANATOMY | BETTER EDUCATION | A MORE INCLUSIVE FUTURE



Limitations of Traditional References

- Anatomy textbooks and reference ranges have historically relied on data from relatively limited populations, with many foundational datasets derived from Caucasian populations¹.
- Imaging research has demonstrated measurable anatomical differences between populations as well as substantial individual variation².
- Across orthopedics³, cardiovascular, neuroimaging⁴, and other domains, these differences can influence reference ranges, implant sizing, surgical planning, and interpretation of diagnostic findings⁵.



CADAVIZ's Approach

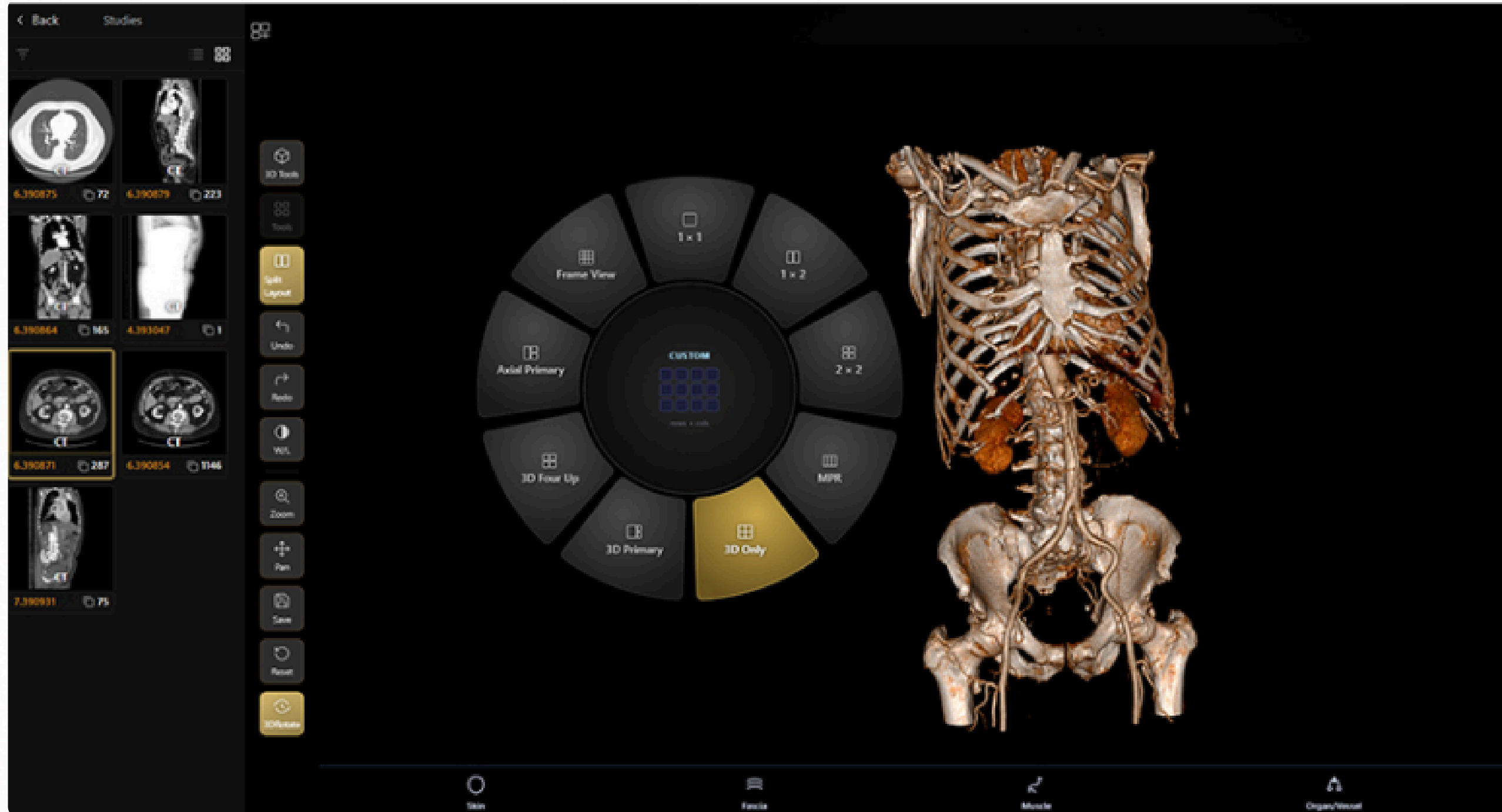
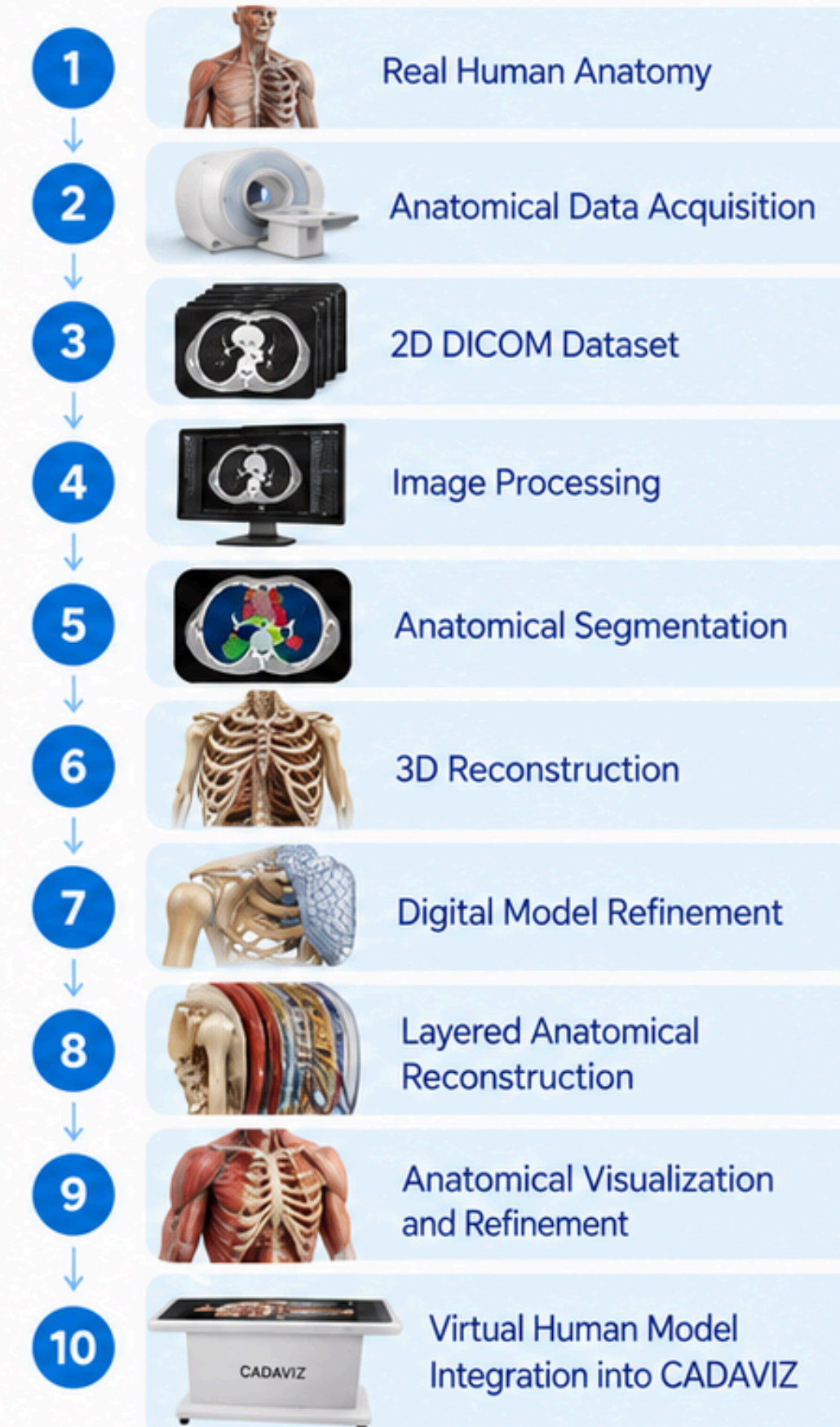
- Incorporates real DICOM imaging and cadaveric data from diverse populations through formal collaborations with medical colleges, teaching hospitals, and anatomy departments.
- Ensures appropriate consent, ethical oversight, data governance, and documented use rights.
- Builds a diverse, patient-derived 3D anatomy repository that reflects anatomical variation across populations rather than relying on a single reference population.



The Real-to-Virtual Pipeline: From DICOM Scan to Interactive 3D Body

Modern CT and MRI provide detailed, patient-specific anatomical information that can be transformed into three-dimensional models. This white paper focuses on DICOM datasets acquired through the MoU and their transformation into interactive 3D anatomy.

The workflow includes



The resulting models preserve the spatial relationships and anatomical characteristics captured in the original donor/patient-derived imaging data while providing an interactive environment for exploration and education.

Real Human Anatomy

Cadaver Suitability for CT Scanning

A fresh, voluntarily donated body is preferred for CT scanning. Ideally, the specimen should be scanned immediately after donation and should not have been stored in a mortuary or mobile cold storage for more than 12–24 hours. If such a specimen is not available, a cadaver with the following characteristics (Table 1) would be preferred.

Table 1. Preferred Cadaver Suitability Criteria for CT Scanning

S.No.	Parameter	Description
1	 Preservation Status	Well embalmed (preferably within the last 6 months) and well preserved.
2	 Cause of Death	Natural cause of death.
3	 Infection Status	No evidence of systemic infection.
4	 Medical History	No known history of malignancy or other conditions that significantly alter normal anatomy.
5	 Physical Condition	Cadaver should not be mutilated, amputated, disfigured, decomposed, or significantly discolored.
6	 Donor Profile	Adult donor (preferably 30–50 years of age), male or female, with a moderate body build.



01 | Anatomical Data Acquisition

CADAVIZ acquires full-body CT DICOM datasets from cadaveric sources through formal Memorandum of Understanding (MoU) with prestigious academic medical institutions across India, providing an established institutional framework for data sharing and use.

The CT acquisition parameters across these institutional datasets include:



Tube voltage
approximately
100–140 kVp



Slice thickness
0.5 mm to
1.25 mm



Reconstruction interval
0.3 mm to
1.0 mm



In-plane spatial resolution
approximately
0.4 mm x 0.4 mm
to 0.8 mm x 0.8 mm



Matrix size
typically
512 x 512



02 | 2D DICOM Dataset

The real-to-virtual process begins with a cadaver full-body CT dataset. The dataset consists of sequential 2D CT images in DICOM format, providing cross-sectional views of the cadaveric anatomy. Combined with the associated metadata and technical documentation, these files provide the foundation for subsequent image processing and 3D reconstruction.



The shared data may include:



Full-body cadaver CT DICOM data in standard format, comprising the original series of cross-sectional images.



Associated DICOM metadata and image headers, providing information required to interpret and spatially reconstruct the CT images.



Technical documentation, supporting the interpretation, processing, and appropriate use of the dataset.



Together, these components form the source dataset for the real-to-virtual workflow, progressing from image processing and segmentation to 3D reconstruction and model refinement.

03 | Image Processing

The acquired DICOM datasets are first prepared for 3D reconstruction. This step is important because the quality and consistency of the source images directly affect the accuracy of subsequent segmentation and 3D model generation.



Why this step matters:

A 3D model is only as reliable as the imaging data from which it is reconstructed. Pre-processing establishes a clean, consistent, and reconstruction-ready dataset, reducing errors that could otherwise propagate into segmentation and the final 3D anatomical model.

The processing may include:



Image quality assessment

To identify incomplete series, poor-quality images, or variations that could affect reconstruction.



Noise reduction

To minimize unwanted image noise while retaining important anatomical details, making structures easier to distinguish.



Artefact management

To address distortions caused by factors such as patient movement, metal implants, or imaging-related artefacts that may interfere with anatomical boundaries.



Slice alignment and consistency

To ensure that sequential images are correctly ordered and spatially aligned, which is essential for generating a continuous 3D volume.



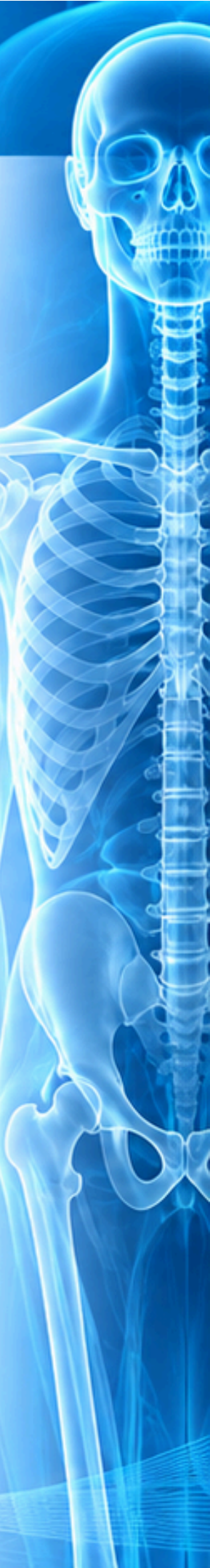
Intensity normalization

Where required, to improve consistency in image intensity and facilitate differentiation of tissues or structures during segmentation.



Dataset preparation for segmentation

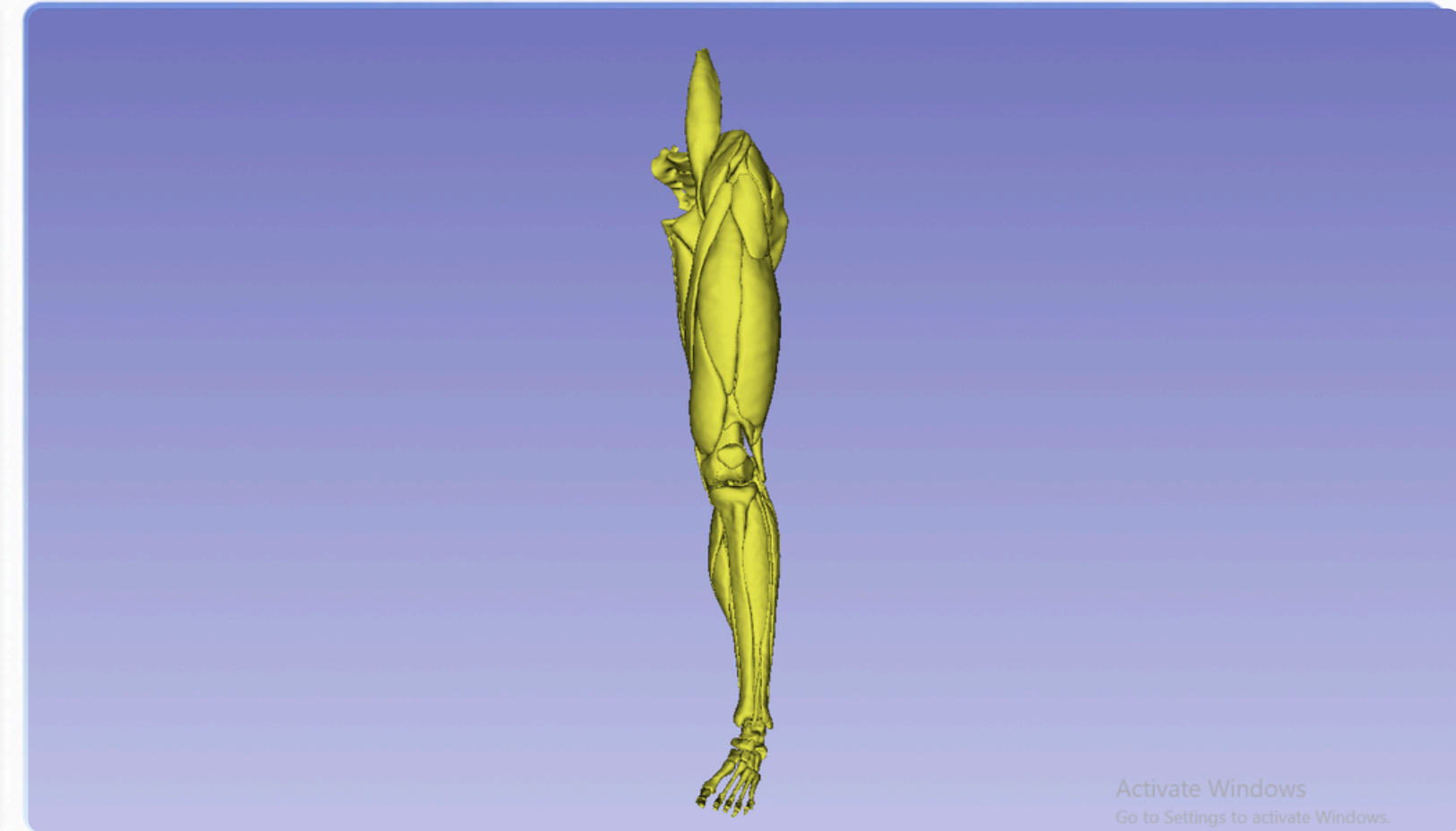
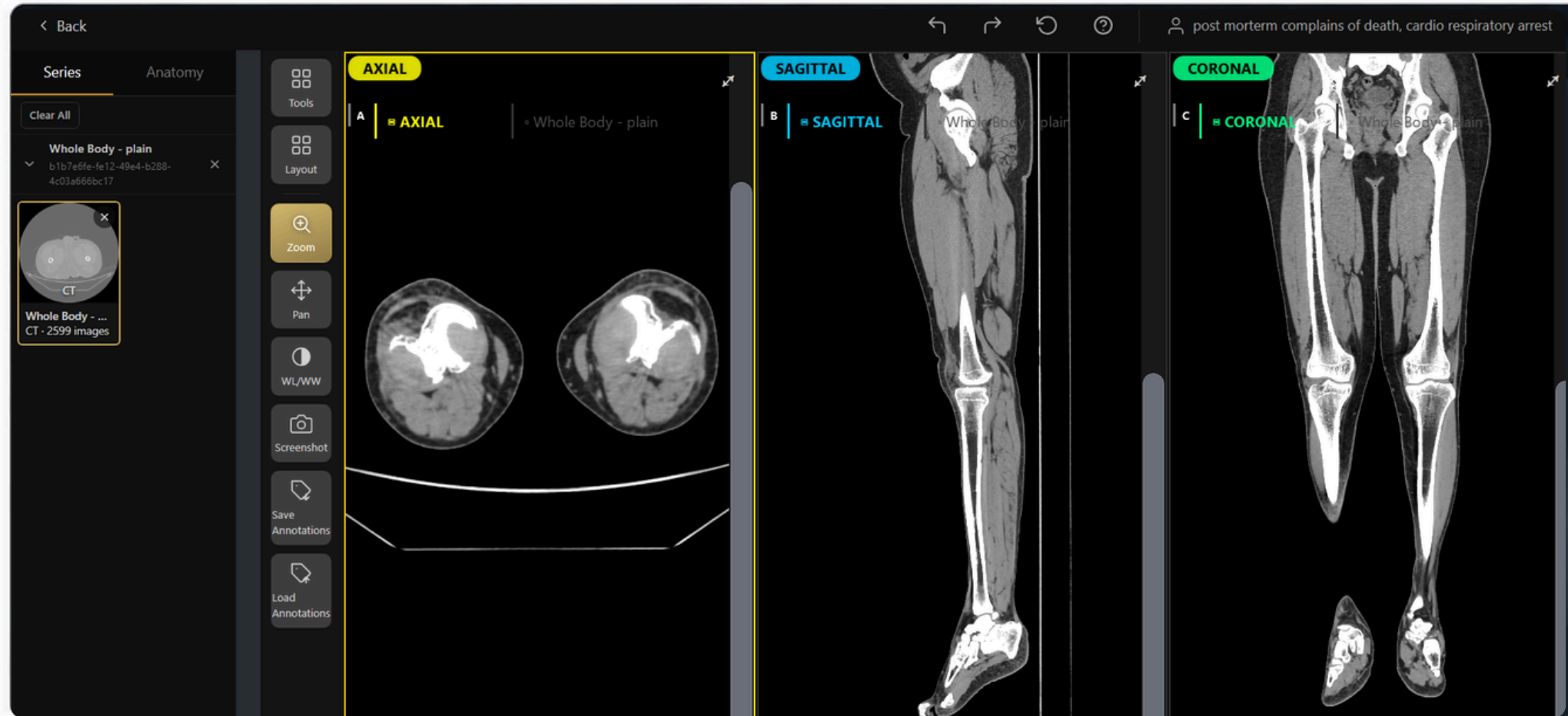
To organize and optimize the processed image series so that specific anatomical structures can be identified and segmented accurately.



04 | Anatomical Segmentation

Segmentation is a critical stage in converting imaging data into meaningful anatomical structures.

Individual tissues, organs, bones, vessels, and other structures are identified and separated from surrounding anatomy based on their imaging characteristics.



Depending on the structure and dataset, segmentation may involve a combination of:



Threshold-based techniques



Region-based segmentation



Manual annotation



Semi-automated workflows



AI-assisted segmentation



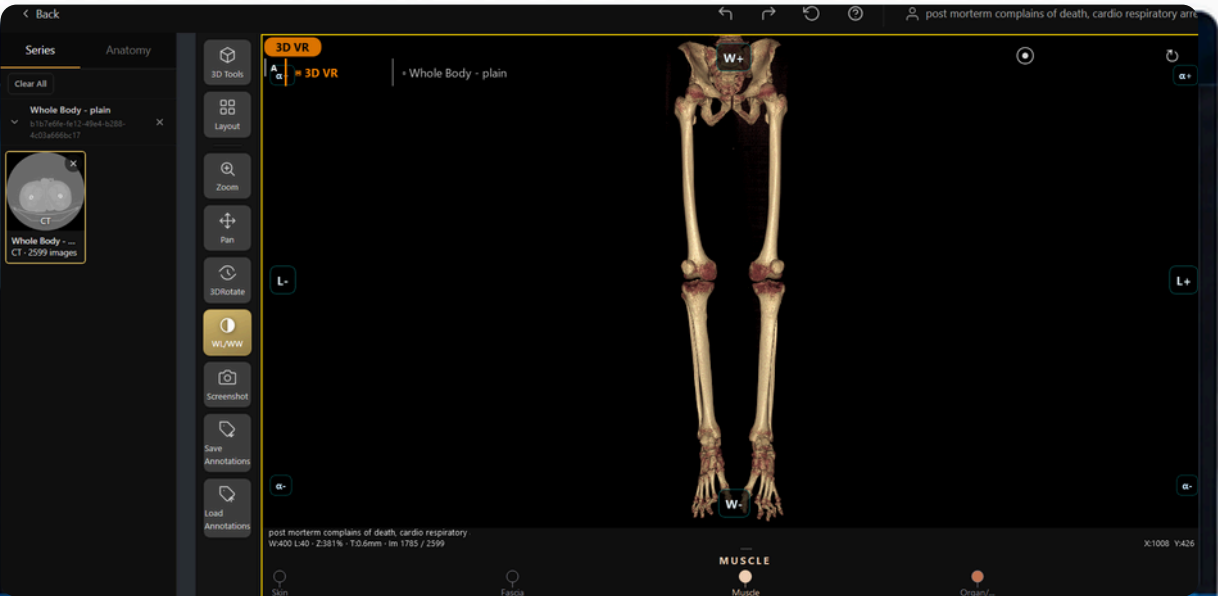
Expert anatomical review



The objective is to create structure-specific volumetric representations while maintaining anatomical continuity.

05 | 3D Reconstruction

At this stage, the processed and segmented imaging data is converted into three-dimensional anatomical structures. Segmented regions are reconstructed as individual 3D models, allowing different anatomical components to be visualized separately and in relation to one another.



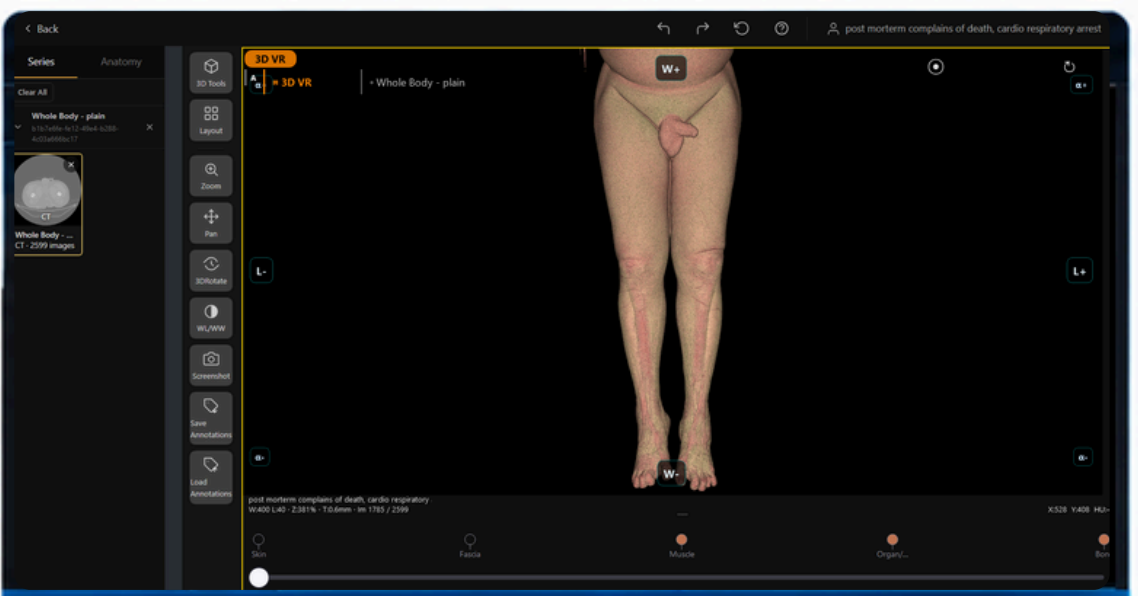
3D – Bone



3D – Muscle



3D – Fascia



3D – Skin

Key steps include:

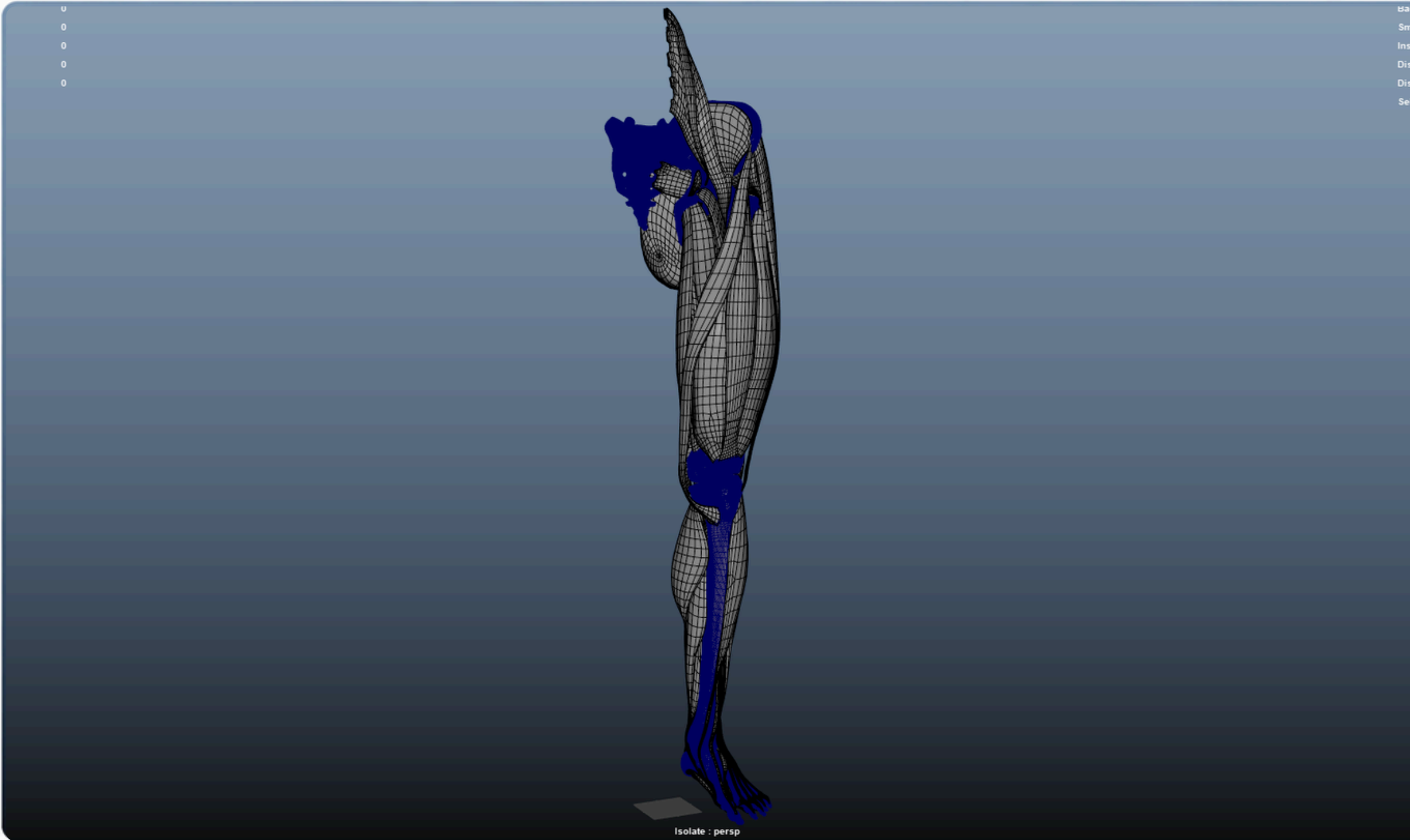
-  **3D model generation**
Segmented anatomical regions are converted into 3D geometry.
-  **Structure-wise reconstruction**
Bones, muscles, skin, and other identified structures can be reconstructed as separate components.
-  **Surface refinement**
Reconstructed models are refined to reduce irregularities and improve anatomical representation.
-  **Layered visualization**
Individual structures can be isolated, combined, or viewed in different layers.
-  **Interactive integration**
The reconstructed models are prepared for integration into the CADAVID interactive 3D environment.



The 2D imaging dataset is transformed into a spatially organized 3D anatomical model, providing the foundation for interactive exploration and anatomical visualization.

06 | Digital Model Refinement

The first stage of refinement converts the reconstructed data into a structured 3D anatomical model, Individual anatomical components are separated and organized so that their spatial relationships can be examined.



Key processes:



3D geometry generation

Converts segmented regions into three-dimensional surfaces.



Structure separation

Individual anatomical components are distinguished and organized independently.



Anatomical boundary definition

Preserves the contours and structural characteristics identified from the source imaging data.



Spatial organization

Maintains the anatomical position and relationship of structures within the reconstructed volume.



Initial model refinement

Removes reconstruction irregularities and prepares the models for further processing.



The original segmented data is transformed into a structured 3D anatomical model, with individual components available for further refinement and visualization.

07 | Layered Anatomical Reconstruction

Once individual structures have been reconstructed, they are progressively aligned and integrated to recreate the anatomical relationships present in the source dataset. This stage moves beyond isolated structures toward a more comprehensive representation of the body region.



Key processes:



Structural alignment

Ensures reconstructed components maintain their anatomical positions relative to one another.



Layer integration

Combines skeletal, muscular, and other reconstructed structures into a coherent anatomical representation.



Depth and spatial relationships

Preserves the relative position of superficial and deeper structures.



Progressive visualization

Allows structures to be viewed individually or in combination.



Anatomical consistency checks

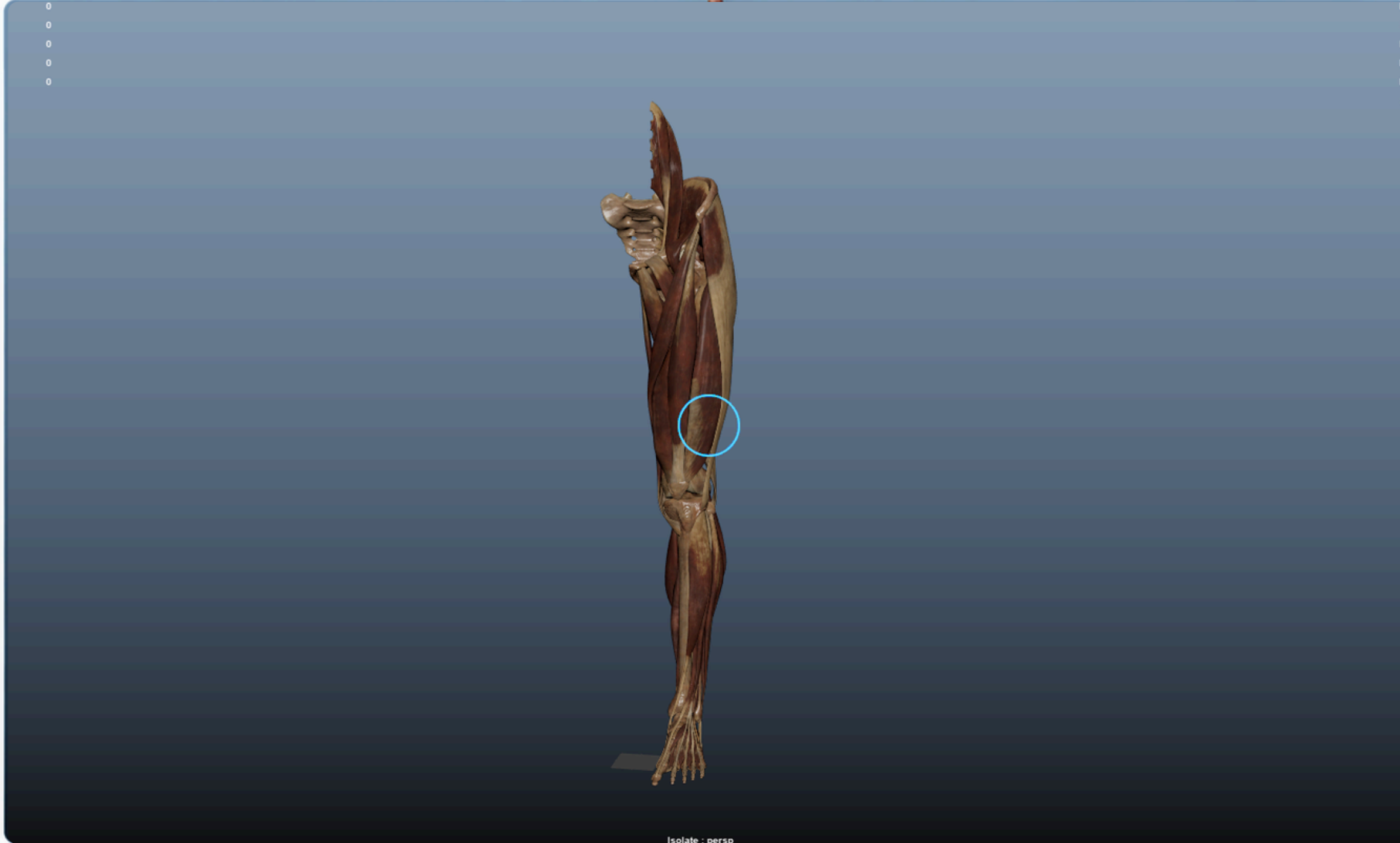
Helps identify and address inconsistencies between reconstructed components.



The individual 3D structures are brought together to create a layered anatomical representation, providing a clearer understanding of their spatial and structural relationships.

08 | Anatomical Visualization & Refinement

The final stage focuses on improving the anatomical presentation, visual differentiation, and interactive usability of the reconstructed models. The refined structures are organized to support exploration of anatomy at different levels.



Key processes:



Surface refinement

Improves the appearance and continuity of reconstructed anatomical surfaces.



Tissue differentiation

Uses appropriate visual representation to distinguish different anatomical structures.



Model optimization

Balances anatomical detail with the performance requirements of interactive 3D visualization.



Layered interaction

Enables structures to be selectively viewed, isolated, or explored in relation to surrounding anatomy.



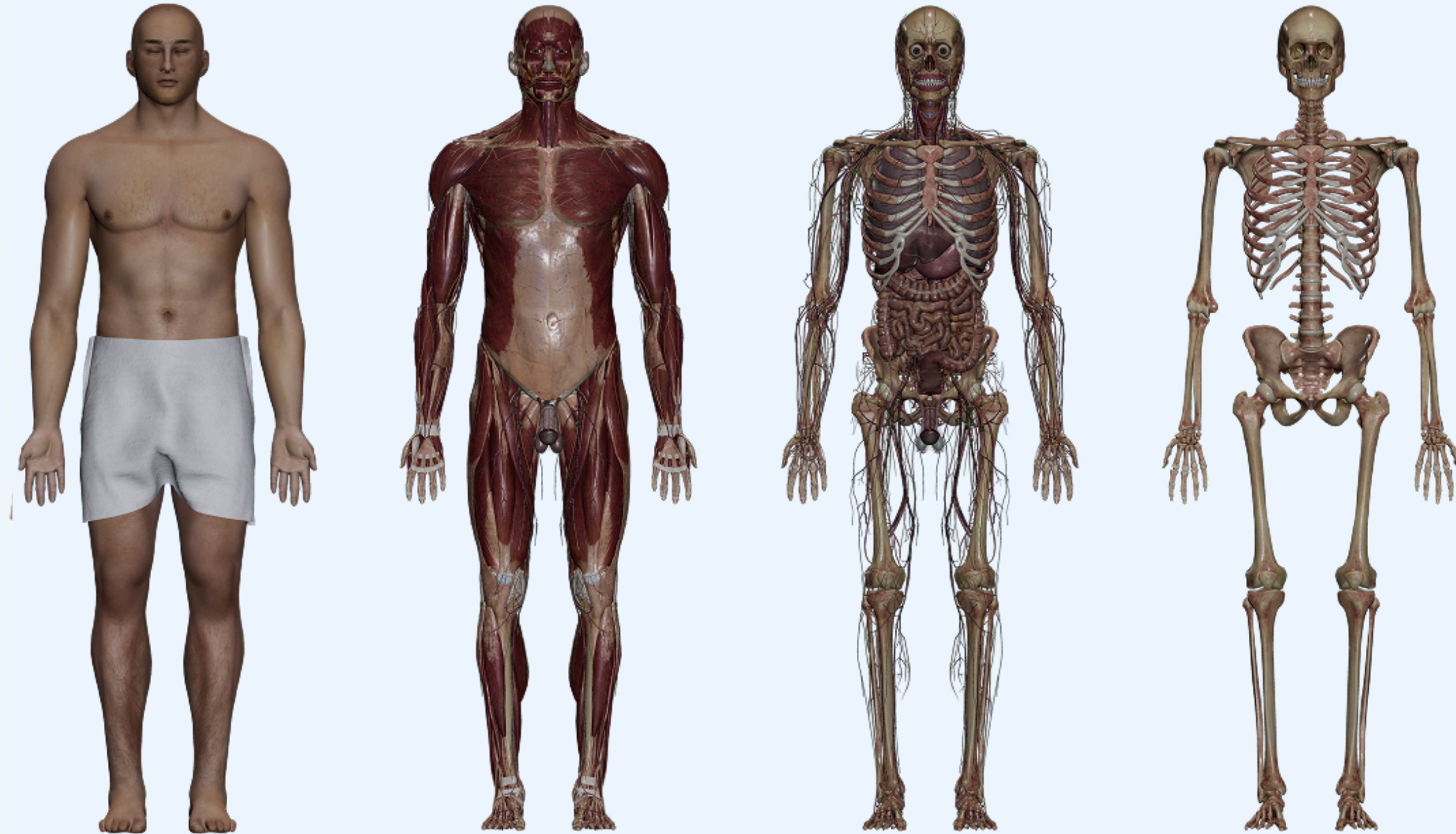
Final anatomical integration

Brings the refined components together into a coherent digital anatomical model.



The reconstructed dataset becomes an interactive 3D anatomical representation, ready for integration into the CADAVID environment for visualization, exploration, and educational use.

Virtual Human Model **Integration into Cadaviz**



The final stage involves integrating the refined anatomical models into the CADAVID. Individual reconstructed structures are assembled and organized to create a coherent three-dimensional representation of the human body.

Key processes:



Surface refinement

Improves the appearance and continuity of reconstructed anatomical surfaces.



Tissue differentiation

Uses appropriate visual representation to distinguish different anatomical structures.



Model optimization

Balances anatomical detail with the performance requirements of interactive 3D visualization.



Layered interaction

Enables structures to be selectively viewed, isolated, or explored in relation to surrounding anatomy.



Final anatomical integration

Brings the refined components together into a coherent digital anatomical model.



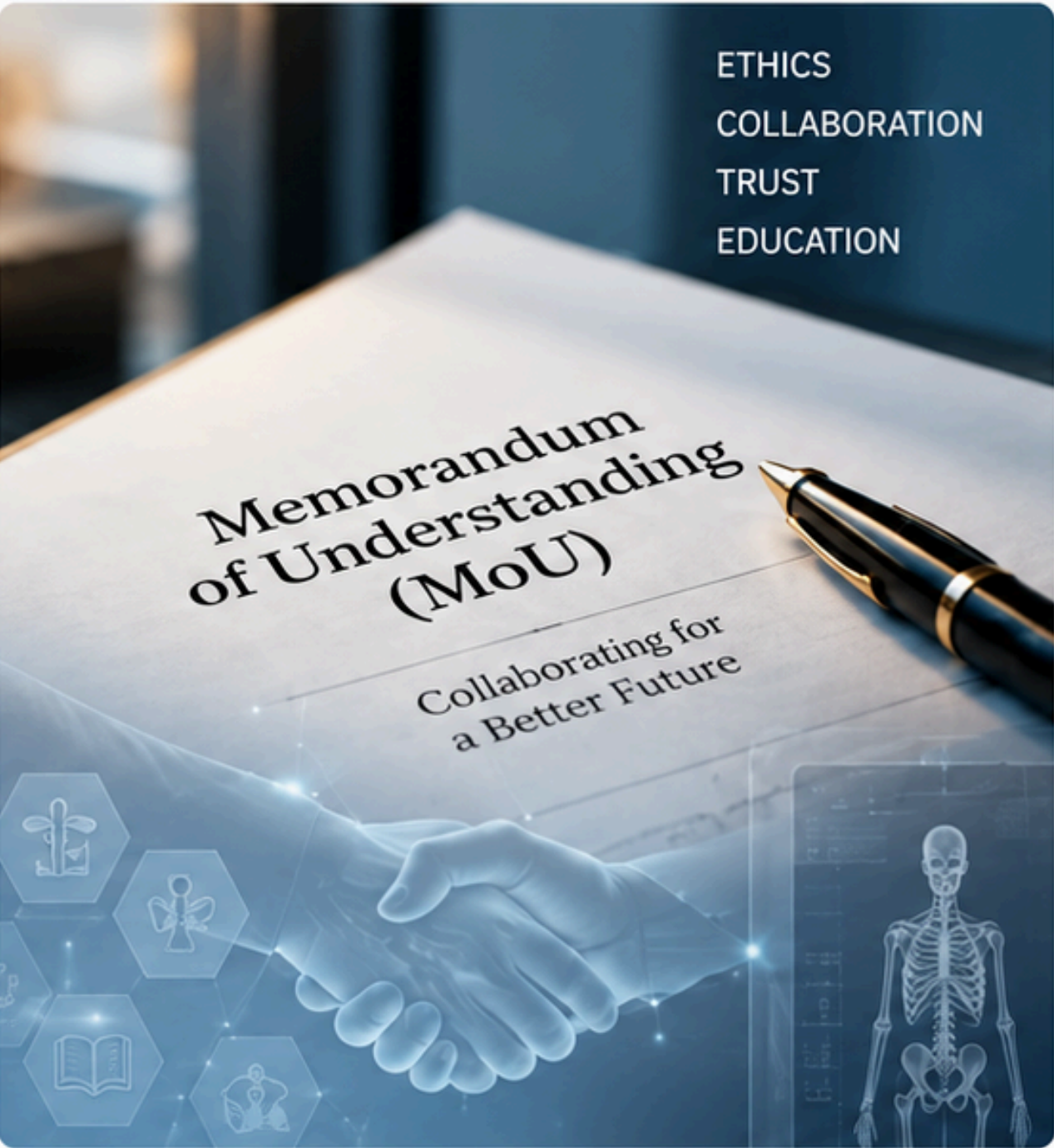
The completed workflow establishes a transition from source DICOM imaging data to an integrated, interactive 3D anatomical model. This process provides a structured method for converting patient- or cadaver-derived imaging datasets into digitally reconstructed anatomical resources while maintaining the spatial organization and anatomical information represented in the source data.

Ethical Data Sourcing & Governance

The anatomical imaging data used in this workflow are obtained under a formal Memorandum of Understanding (MoU) governing the sharing and permitted use of the dataset. The MoU provides the institutional framework for the acquisition, handling, processing, and use of the shared data.

Key processes:

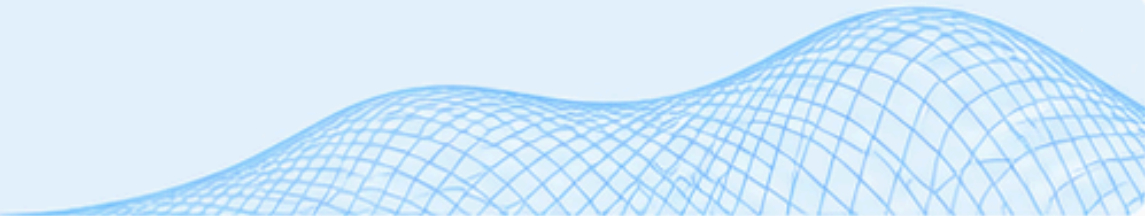
	Formal data-sharing framework	The dataset is shared under an established MoU defining the respective responsibilities and permitted use of the data.
	Ethical sourcing	The source data are acquired through appropriate institutional processes and permissions.
	Consent and authorization	Applicable consent, authorization, and institutional requirements are addressed as part of the data-acquisition process.
	Privacy and confidentiality	Appropriate safeguards are applied to protect information associated with the individuals represented in the dataset.
	Data governance	Access, storage, processing, and use of the data are governed by defined requirements and agreed conditions.
	Documented use rights	The MoU establishes the scope and conditions under which the shared data may be used for the defined purposes.



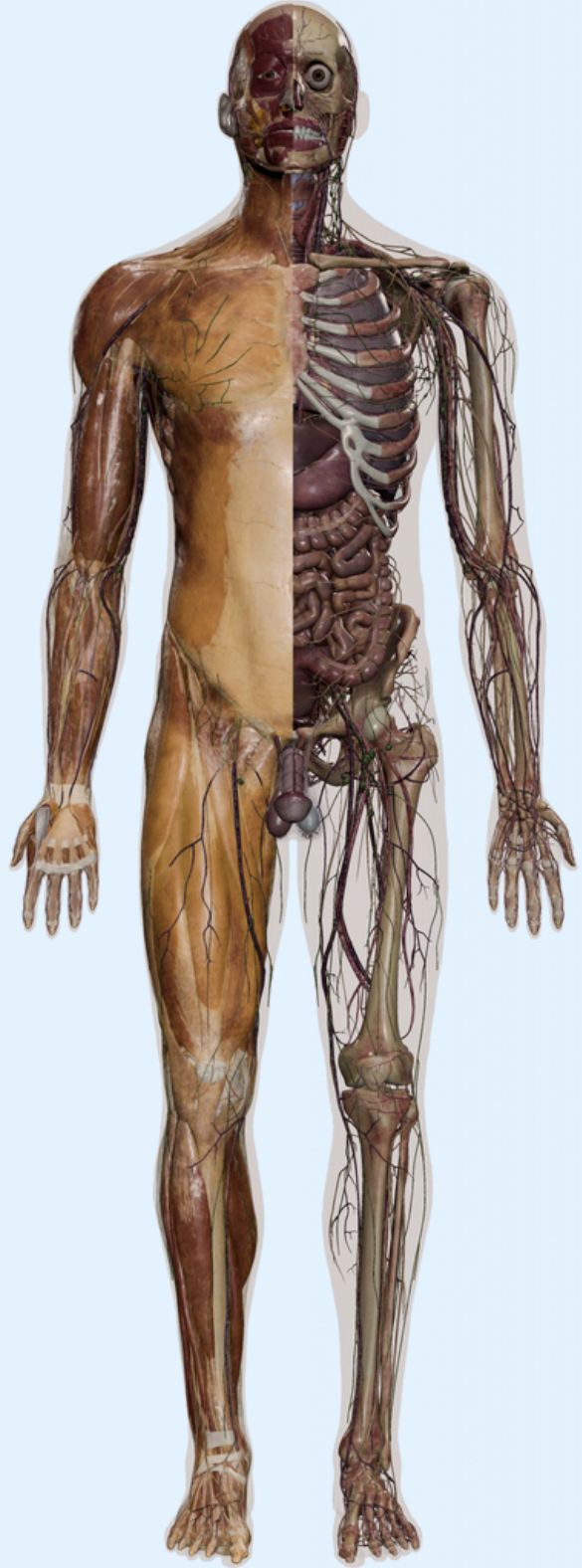
ETHICS
COLLABORATION
TRUST
EDUCATION



Responsible data use today, for better medical education tomorrow.



Conclusion



Traditional anatomical references have often relied on limited reference populations, despite evidence of substantial population-level and individual anatomical variation. This underscores the need for resources that better represent the diversity of human anatomy.



The real-to-virtual workflow demonstrates how cadaver-derived full-body CT DICOM data can be transformed into interactive 3D anatomical models through processing, segmentation, reconstruction, and refinement.



Through ethically sourced data acquired under formal MoUs with prestigious academic medical institutions across India, CADAVID provides a structured pathway for developing a growing repository of real human anatomy.



By moving beyond a single standardized anatomical reference toward diverse, real anatomical datasets, CADAVID provides a foundation for more representative digital anatomy.

Diverse data. Deeper understanding. A more inclusive future for anatomical education.

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Building knowledge on a stronger foundation.