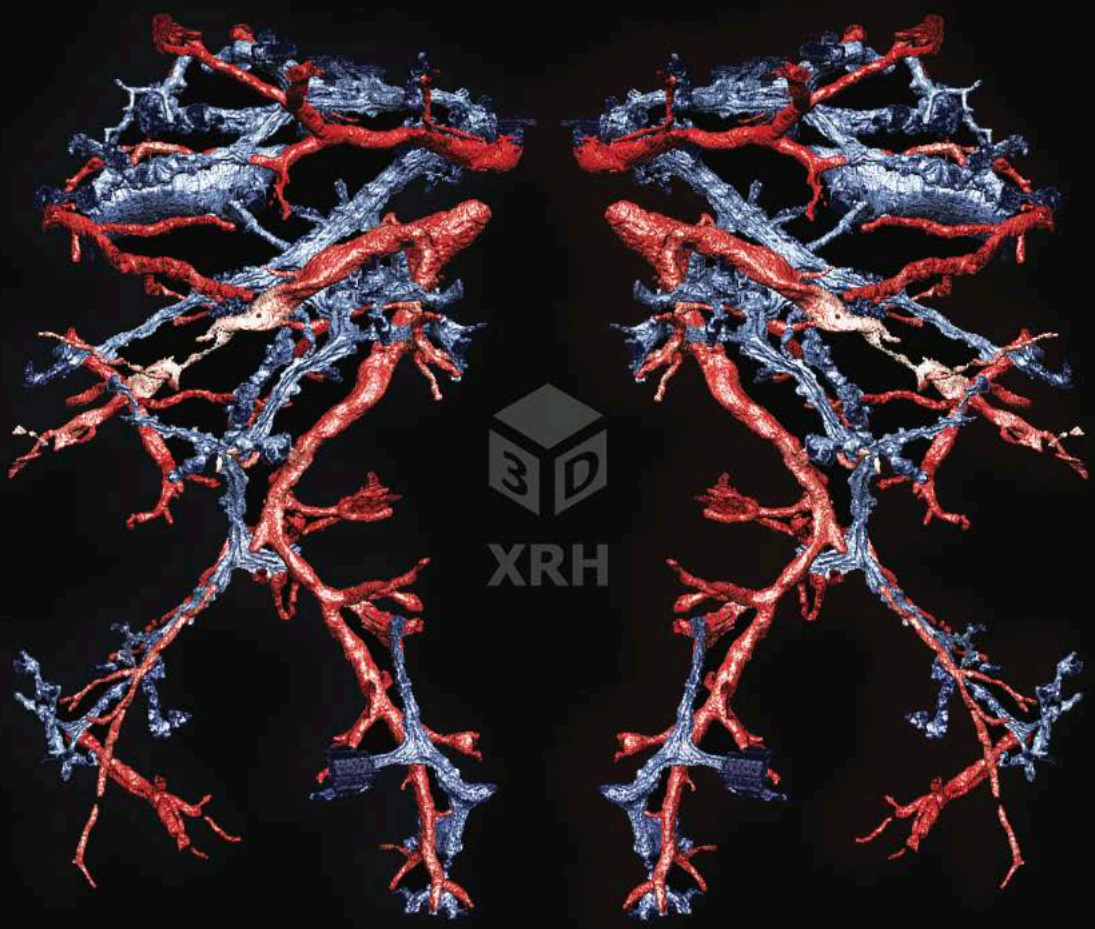
University of Southampton

NXCT National X-ray Computed Tomography

3D X-RAY HISTOLOGY
REVOLUTIONISING BIOMEDICAL IMAGING



µ-VIS X-RAY IMAGING CENTRE

microtomographic Volume Imaging at Southampton

OPPORTUNITIES IN 3D VOLUME IMAGING AT THE UNIVERSITY OF SOUTHAMPTON

The µ-VIS X-Ray Imaging Centre is University of Southampton's dedicated centre for CT and founding partner of the National Research Facility for lab-based X-ray CT (NXCT). The centre combines state-of-the-art equipment and 25 years of experience, plus the expertise of 40+ academic staff from across the University, offering a unique integrated resource for advanced 3D imaging.

The benefits offered by CT imaging:

- The ability to comprehensively visualise inaccessible and/or opaque materials and structures in 3D
- High spatial resolution (to submicrometre level if necessary)
- Detailed 3D (volume) parameterisation for characterisation and modelling
- Non-destructive

Consultancy services

µ-VIS offers a range of services to external institutions (academic and industrial) including:

- feasibility assessments
- experimental design and planning
- 3D volume imaging
- image analysis (visualisation and morphometry)
- metrology
- assembly analysis
- image-based modelling
- correlative imaging
- *in situ / in operando* imaging
- training

Computational facilities

High-performance workstations for development and optimisation of novel analysis and workflows.

- workstations with up to 1 TiB RAM & 128 threads
- dedicated fast data transfer network
- high speed storage with over 700 TB raw capacity
- leading commercial and open-source software

CT Imaging equipment

Large-scale scaning

2x customised walk-in bays up to 450kVp

- imaging volumes in excess of 1x1x2 m
- sample weight up to 200 kg & large user labyrinth
- 225 kVp, 300 kVp, 450 kVp X-Ray sources
- ~3 µm up to 300 kV, 50 µm at 450 kVp & 1 mm up to 1500W
- 4 MP & 9 MP Flat Panel detectors + CLDA detector
- helical scanning, laminography, scatter compensation

Mid-scale and High-throughput scanning

3x all-purpose CT and radiographic inspection systems up to 225 kVp

- resolution down to 1.5 µm
- samples to ~300 mm and 50 kg
- 10x & 14x automatic sample exchange racks

High-resolution scanning

1x sub-micron resolution X-ray microscopy system

- 30 -160 kVp, magnification objectives up to 40x
- 0.7 µm true spatial resolution
- phase-enhanced contrast imaging mode

Biomedical imaging and X-ray Histology (XRH)

2x in-house designed systems

- optimised for biomedical imaging & XRH
- resolution down to 1.5 µm
- samples up to ~300 mm and up to 15 kg
- high-throughput and cryo-imaging
- 4 MP & 7.5 MP FP detectors
- photon-counting detector

Preclinical imaging

2x small animal *in vivo* imaging systems

** Systems managed by the Biomedical Imaging Unit*

- correlative X-ray + fluorescence/luminescence imaging
- ~10 µm in vivo spatial resolutions
- integrated physiological monitoring
- gating mode

Manufacturers

Nikon Metrology UK Ltd | diondo | Zeiss | Dectris
PerkinElmer | Deben | Oxford Cryosystems

The µ-VIS Approach:

Imaging:
- system flexibility
- automation
- advanced methods

+

Data handling:
- fast, cost-effective HPC (GPGPU)
- end-to-end workflow, interoperability

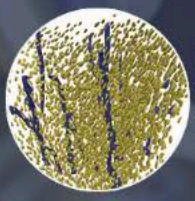
+

Computer vision:
- training
- established resources
- advanced algorithm implementation

CAPABILITIES & APPLICATIONS

UNIQUELY FLEXIBLE, MULTI-SCALE HIGH-ENERGY µCT

'walk in' custom-built bays equipped with multiple sources and detectors; designed for versatility and large-scale imaging



HIGH RESOLUTION

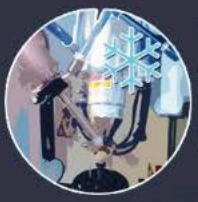
sub-µm spatial resolution and phase-enhanced constrast capability

***in situ* TESTING**

number of *in situ* rigs (incl. load, environment, and flow control) that can be mounted within lab-CT and SR-CT systems

X-RAY VIDEOGRAPHY

real-time X-Ray imaging for functionality inspection



'CRYO' CT

sub-zero degrees imaging of frozen specimens, tissue imaging in OCT, imaging in 'chilled' environment, etc

SCATTER COMPENSATION

single-slice and volume scatter-free imaging modes for stunning image sharpness and contrast of dense structures

4D-CT

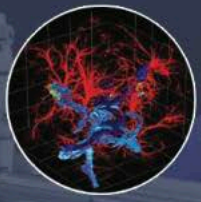
time-resolved *ex-situ* and *in situ* µCT imaging of deformation and/or failure mechanisms within samples

SRµCT

25 years of experience at worldwide synchrotron facilities

PANEL-SHIFT RADIOGRAPHY

horizontal and vertical field of view expansion resulting in up to ~9,000 x 10,000 pixels (c. 1.6 x 2.0 m) detector size



DATA PROCESSING & ANALYSIS

access to high-performance workstations with multiple 3D image analysis software packages

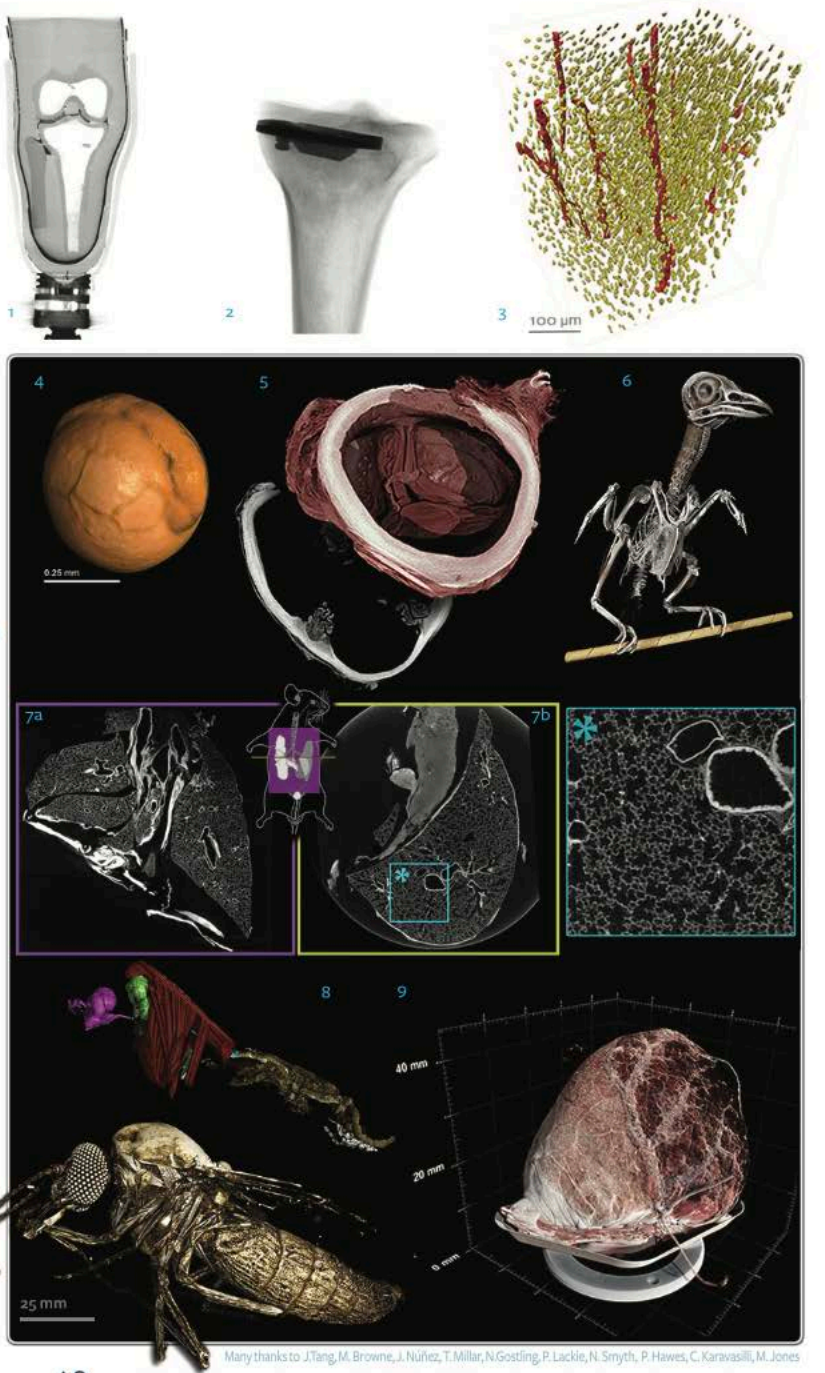
APPLICATIONS

- 3D (volume) visualisation
- Defect analysis
- FE model generation (meshing)
- Densitometry and porosity characterisation
- Actual-nominal comparison
- Petro-physical characterisation
- CT metrology
- Process evolution (time-resolved imaging)
- Digital Volume Correlation (DVC)

RESEARCH AREAS

- 3D X-ray Histology
- Biomedical engineering
- Pharmaceutical technology
- Biomaterials
- Tribology & Failure analysis
- Manufacturing engineering
- Additive manufacturing
- Engineering materials and structures

GALLERY



1. µ-CT image of an artificial residuum/socket interface
2. CoCr implant in human tibia specimen
3. Cortical microstructure of murine bone: canals in red & osteocyte lacunae in yellow
4. Zebrafish embryo
5. Single slice and 3D rendering of a porcine heart valve
6. Magpie (juvenile)
7. Unstained FFPE mouse lung imaging. Coronal [a] & transverse [b] single XRH slices
8. Culicoides biting midge
9. 'Cryo'-imaging of fresh-frozen inflated porcine lung biopsy

VIDEOS

scan and follow the QR codes; from left to right:

1. X-ray µCT of a magpie juvenile
2. µCT imaging, segmentation and reconstruction of a mouse embryo
3. X-ray µCT of a biting midge
4. 3D X-Ray Histology and analysis of a squamous cell carcinoma
5. Horse placenta microstructure imaged by 3D X-ray Histology
6. µCT to Virtual Reality (VR) at µ-VIS X-Ray Imaging Centre

Many thanks to J.Tang, M. Browne, J. Núñez, T. Millar, N.Gostling, P. Lackie, N. Smyth, P. Hawes, C. Karavasilli, M. Jones

VIDEOS

1 2 3 4 5 6

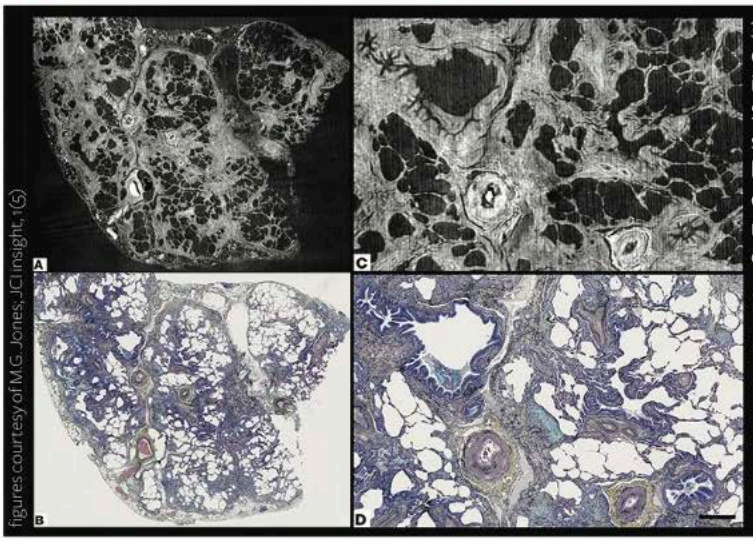
www.youtube.com/@muvis-tomography

To find out more about µ-VIS and how to gain access to our facilities and expertise please email us or visit our website

muvis@southampton.ac.uk
www.xrayhistology.org
www.muvis.org

CASE STUDIES

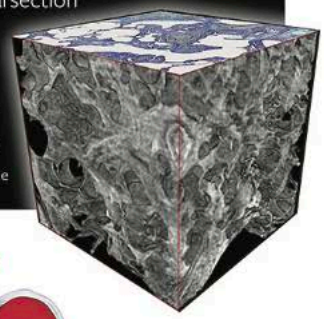
3D Correlative Imaging of Human Lung Tissue



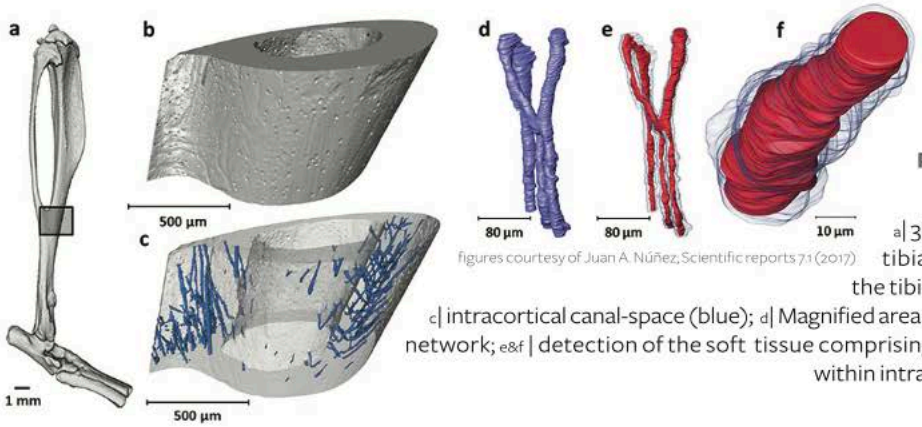
figures courtesy of M.G. Jones, JCI insight, 1(5)

3D X-Ray Histology of a biopsy sample with diagnosis of usual interstitial pneumonia/ idiopathic pulmonary fibrosis (IPF). Side-by-side comparison of a single µCT slice (A&C) and the corresponding a histological section stained with Movat's Pentachrome (B&D) demonstrating that tissue microstructure is clearly visible in the µCT dataset at high contrast levels - Scale bar: 500 µm

3D volume renderings with coregistered histological section displayed on the superior surface for reference Cube 2 mm/side



Calcified Bone Matrix and Intracortical Vasculature Visualisation



figures courtesy of Juan A. Núñez, Scientific reports 7:1 (2017)

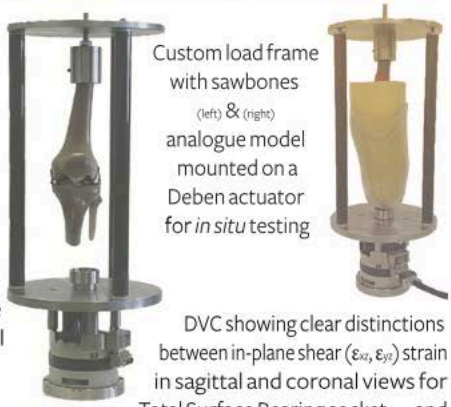
Simultaneous visualisation using Synchrotron X-ray Phase contrast µCT

a| 3D rendering of mouse tibia; b| 3D rendering of the tibiofibular junction and c| intracortical canal-space (blue); d| Magnified area of the 3D intracortical network; e&f | detection of the soft tissue comprising blood vessels (red) within intracortical canals (blue)

Image-based Modelling for Evidence-based Prosthetic Socket Design

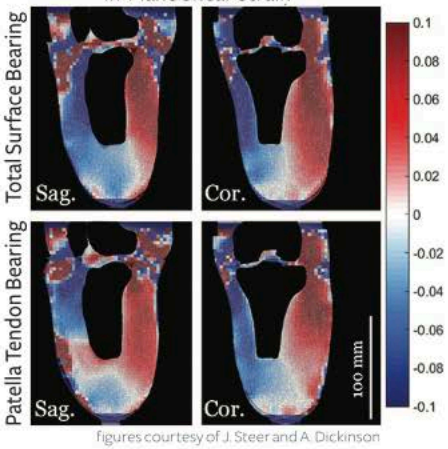
Development of computer models to let prosthetists predict socket fit, validated against Digital Volume Correlation strain measurements.

X-CT is being used to perform DVC to visualise the strain inside a novel residual limb model, simulating transtibial amputation.



Custom load frame with sawbones (left) & (right) analogue model mounted on a Deben actuator for *in situ* testing

DVC showing clear distinctions between in-plane shear (ε_{xz}, ε_{yz}) strain in sagittal and coronal views for Total Surface Bearing socket(top) and Patellar Tending Bearing socket(bottom)



figures courtesy of J. Steer and A. Dickinson

Find out more

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