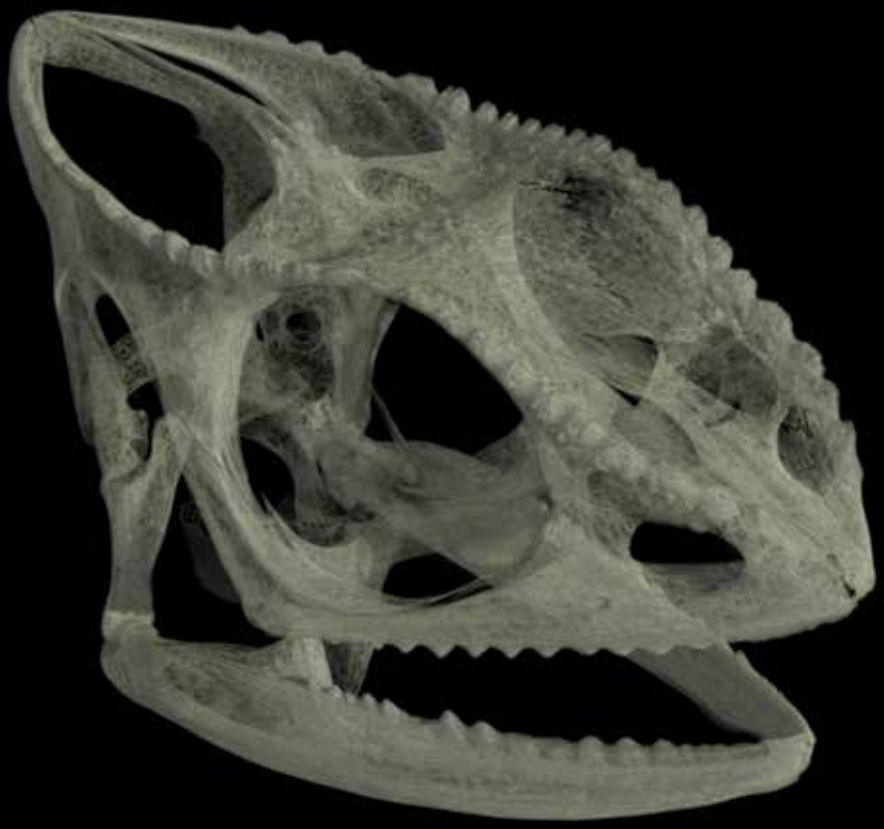
Engineering and the Environment

UNIVERSITY OF Southampton

Inside information.
Advanced X-ray computed tomography



Opportunities in 3D Volume Imaging at the University of Southampton

The University has invested over £3m in the newly launched µ-VIS high resolution X-ray computed tomography (CT) facilities. The facility offers state-of-the-art equipment and draws on the expertise of over 40 academic staff from across the University. The centre specifically aims to provide a holistic approach to advanced 3D imaging, supporting all steps between original domain problem/query, through to verified, publishable conclusion.

The benefits offered by CT imaging:

- The ability to comprehensively visualise inaccessible and/or opaque materials and structures in 3D
- High levels of spatial resolution (down to sub-micron, if necessary)
- Essentially non-destructive
- Detailed 3D parameterisation for characterisation and subsequent modelling

Services

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

- Production of images
- Image analysis (sample visualisation and measurement)
- Defect detection
- Actual-nominal comparison
- Assembly analysis
- FE model generation (meshing)
- Extraction of STL surface models and point clouds
- Research collaboration

Facilities

The facility comprises of five advanced CT systems:

- 225kv Nikon/Metris HMX ST (~1-10µm resolution capability, depending on configuration. Max. sample Ø~300mm/50kg).
- 225/450 hutch Nikon/Metris Custom Design (~3-50µm resolution capability, depending on configuration. Max. sample dimensions: ø 1m, length 2m, weight 100kg).
- Nikon/X-tek Benchtop CT160Xi (~3µm resolution capability. Max. sample Ø ~90mm).
- Gatan XuM nanoCT (~200nm resolution capability. Max. sample Ø ~2mm).
- Skyscan 1176 in vivo small animal scanner

Analysis Suite:

Eight high specification workstations supporting a suite of commercial and non-commercial visualisation and analysis tools (including mesh and point cloud generation)

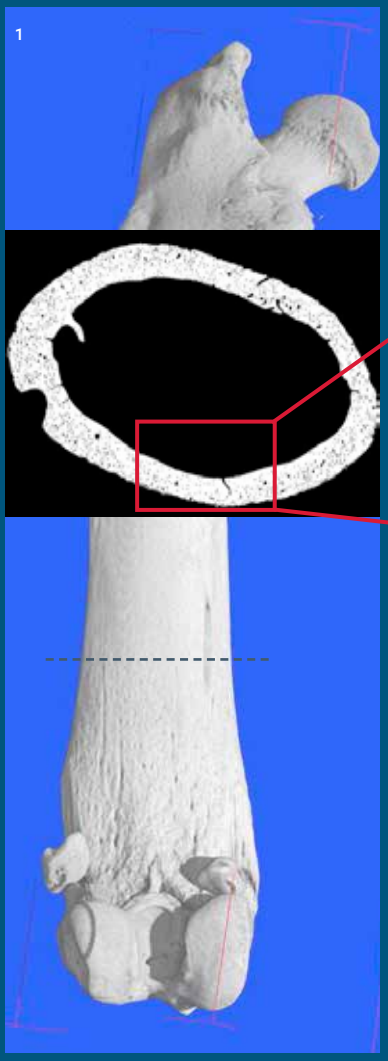
– Avizo
– VGStudio MAX
– Simpleware
– IDL
– LAVISION DaVIS
– Digisens

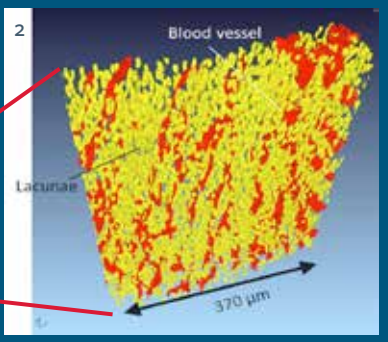
The µ-VIS Approach:

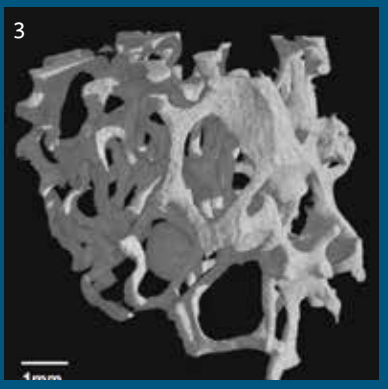
Imaging:	+	Data handling:	+	Computer vision:
- System flexibility - Automation - Advanced methods		- Fast, cost-effective HPC (GPGPU) - End-to-end workflow, interoperability		- Training and established resources - Advanced algorithm implementation (esp. feature extraction)

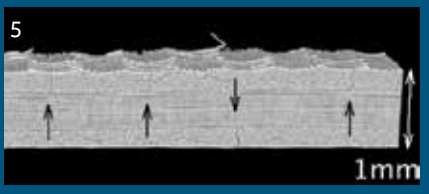
1/2 3D rendering of a whole femur of an OPN knockout mouse (left) and inspection of microporosity of cortical bone (right) with lacunae coloured yellow and blood vessels red.

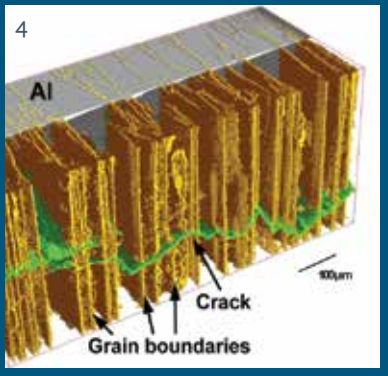
3. Open cell metallic foam.
4. Aluminium alloy showing the interaction between a growing fatigue crack and grain boundaries.
5. 3D rendering of transverse ply crack array in CFRP cross-ply laminate.











Applications: current projects and application areas

Project	Applications
Engineering materials and structures	Metallic, polymeric, composite and ceramic; Resolutions to sub micron levels; Input to multi-physics modelling
Genetics	Numerous phenotype studies; Efficient use of precious animal resources
Cardio-vascular health	Animal model and ex vivo imaging of soft tissue
Respiratory health	Lung stereology; Animal model and ex vivo
Regenerative medicine	Tissue engineered constructs in vitro and in vivo musculoskeletal, cardiac, endothelia, and cardiac tissues including stem cells
Geotechnical testing	In-situ geophysical monitoring; Petro-physical characterisation; Structural quantification down to µm-scale
Orthopaedic engineering and biomaterials	Whole implant constructs down to mechanics of the bone at the ultra-structure level
Surface science	Many material types and densities; In-situ capabilities; Input to multi-physics modelling
Archaeology	Applications in palaeopathological, forensic and taphonomic modification studies of osteological remains; Ceramics; Reconstruction with computer graphics

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

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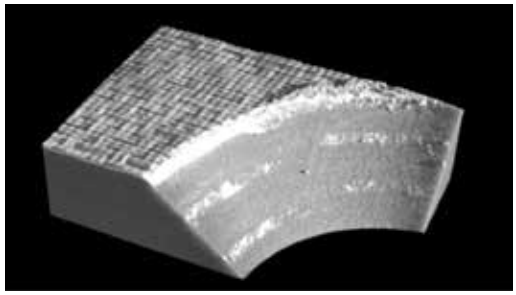
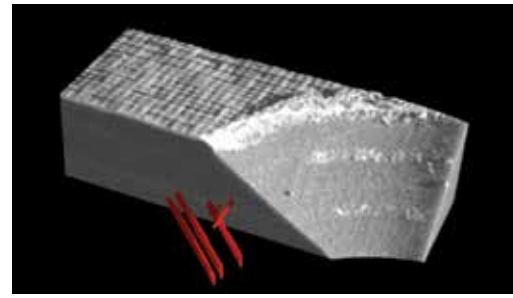
www.southampton.ac.uk/muvis

Case studies





Situation

Bolt holes prepared in thick CFRP laminates revealed unexpected surface cracks within the countersink.

The extent, geometry and relation to the manufacturing process were unknown.

What we did

High resolution CT was performed on simply prepared samples using lab micro-focus facilities at the university.

Volume images were prepared to show the 3D visualisation of the internal crack (red in the images above) and their relation to the ply structure and geometry.

Impact

The extent and interconnected character of the cracking was fully revealed in 3D.

An unexpected role of lubricant in crack formation was identified which was not anticipated by the client.

Time-consuming and relatively uninformative metallographic investigation was avoided.

Lubrication strategy was upgraded, improving component quality.

Situation

A small pot with coins dating to the 2nd century found in the Selby area, East Riding of Yorkshire.

Excavating and cleaning just a single coin can take hours or even days.

What we did

High resolution CT was performed and volume images were generated to visualise details of coins in 3D. The University of Southampton and the owners of the artefacts have plans to share the data with the public through future exhibitions and online.

Impact

Archaeologists were able to examine and identify coins quickly and without the need for conservation treatment. This approach has potential for examining many other archaeological objects faster, cheaper and with less intervention than excavation.

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