New X-ray research facilities at Southampton University

Nikon Metrology systems support micro visualization in industry and academia

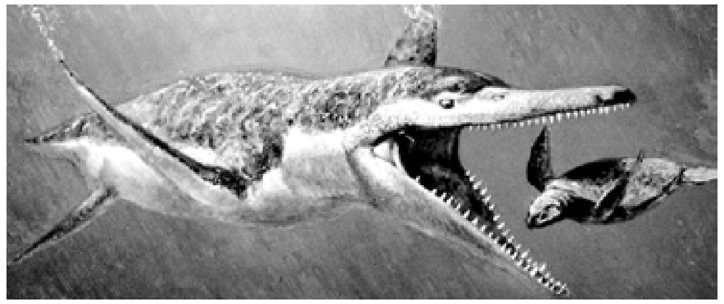
A new groundbreaking research center designed to examine materials and structures across many length scales has been launched at the University of Southampton. The µ-VIS (micro-vis) X-ray Imaging Center examines the internal structure of objects in incredible detail. It produces high-resolution 3D images that support research in fields ranging from biomedical science to engineering, and archaeology to modern environmental science. The new £2.2 million research facilities provide micro-focus computed tomography (CT) imaging to exceptional energy and length scales (up to 450 kV, imaged volumes in excess of 1 cubic meter), whilst offering complementary resolution capabilities down to 200nm.

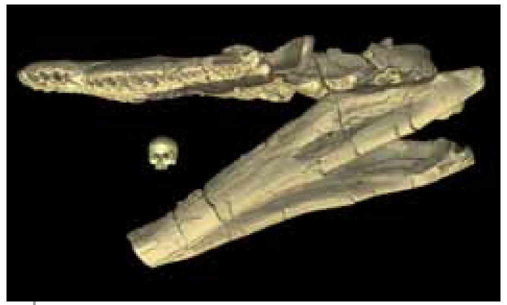
Looking inside objects at very detailed levels

Inaugurated on September 16th, 2011, Southampton's µ-VIS Imaging Center is equipped to achieve breakthroughs in the engineering, biomedical, environmental and archaeological sciences. The center integrates state-of-the-art imaging hardware, world-class computing and image processing expertise to acquire and process the 3D data that is needed to break new ground.

Three systems installed at the state-of-the-art X-ray Imaging Center are from Nikon Metrology, namely a custom-designed Hutch, with a 450 kV and 225 kV source as well as a flat panel and line array detector, a modified XT H 225 ST cabinet system and a 160kV Xi Benchtop scanner. The Centre additionally incorporates a Gatan XuM/Zeiss Evo MA25 nanoCT system and a SkyScan1176 for in vivo CT (small animal studies).

The µ-VIS scanners work in much the same way as a medical CT scanner, but at higher resolutions, by taking thousands of X-ray views to build up a 3D image of the examined object. Beautifully rendered CT images illustrate its capability in measuring internal and external dimensions and the critical insight it provides through the additional fourth dimension of material density. Looking inside objects at this level of detail in a non-destructive way is a huge advantage when studying objects that either cannot be dismantled or are too unique, delicate or complicated to take apart.





Comparison of Pliosaur skull vs. human head

> *"The huge Nikon Metrology X-ray bay is ideal for scanning such large, dense lumps of fossil.*

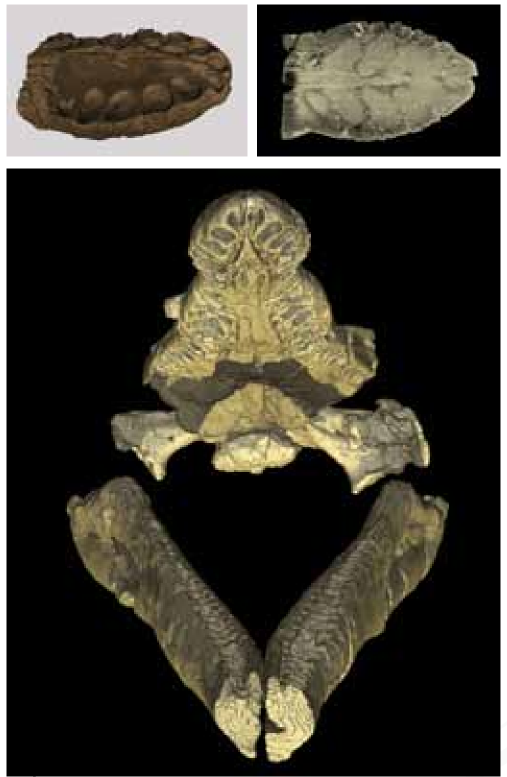
A ferocious predator's jaw

The opening seminar at the Center's inauguration event was organized as a symposium focusing on application results. Professor Ian Sinclair, the Head of the µ-VIS Center, discussed the Weymouth Pliosaur research where a 2.5-meter long jaw has been scanned and reconstructed using the custom Hutch system, as widely reported on the BBC last December.

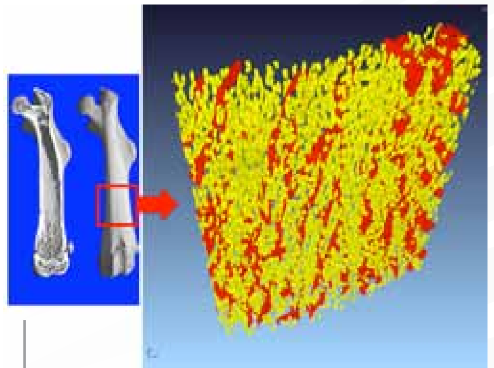
The huge Nikon Metrology X-ray bay is ideal for scanning such large, dense lumps of fossil. The X-rays are helping to build up a 3D picture of this ferocious predator, which terrorized the oceans 150 million years ago. It concerns an aquatic reptile with a huge bulky body, paddle-like limbs and an enormous crocodile-like head packed full of razor-sharp teeth. By looking at the inner architecture of the skull, scientists may gain new insights into the species and its evolution.

Other natural specimen studies include the scanning of large numbers of mice as models for numerous human conditions, including osteoporosis. Researchers have for example recently used the XT H 225 ST equipped with a transmission target to scan the bones of gene knock-out mice elucidating for the first time the critical role of certain proteins in bone fragility. The pore analysis method applied illustrates how much insight could be gained through creative X-ray image and CT slice post-processing.

Important issues for future farming were investigated via quantification of the structure of soils and development of living plant roots, supporting multi-physics modelling of how this may affect both irrigation and phosphate utilisation.

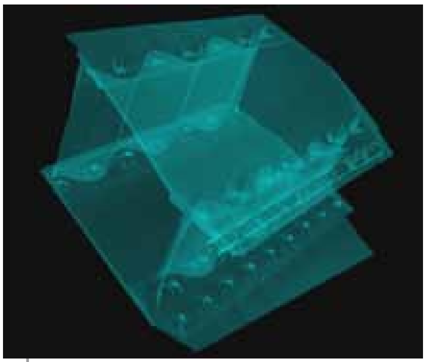


3D rendering and CT image slice of a Pliosaur jaw, reconstructed using scans taken in the Nikon Metrology bay.



Complementary microfocus and synchrotron CT imaging of murine bone geometry and ultrastructure (P. J. Thurner et al., Bone, 46 (2010), pp. 1564-1573 doi:10.1016/j.bone.2010.02.01)

The impressive XT H 450 system offers several microfocus X-ray source options along with flat panel and linear array detectors.



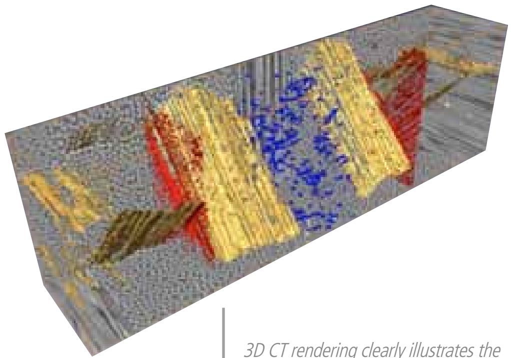
3D rendering of an aircraft wing part (~400mm across) scanned using a 450kV X-ray source and a curved linear detector array.

X-ray makes the difference in engineering insight

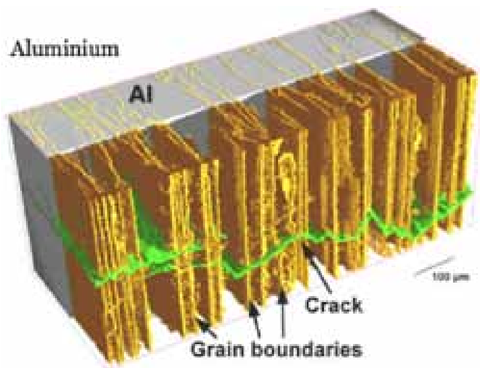
Industrial engineering benefits greatly from the broad application reach of CT scanning. Groundbreaking research involved the study of carbon fiber/epoxy used to coat aluminum gas bottles to reduce weight. The research looked into the resistance to damage using all scales of the µ-VIS Imaging activities. The full engineering components were initially scanned in their intact form, with subsequent targeted higher resolution sub-sampling elucidating structures at individual ply, tow and, ultimately, discrete carbon fibre levels. This work has allowed established theories of fibre failure modes to be explicitly compared with experimental results for the first time at both coupon and engineering component levels.

A railway engineering study reported on the effect of long term use of the ballast underneath railway sleepers (railroad ties). The crushed-stone ballast facilitates drainage of water and distributes the load from the railway sleepers. Taking several scans of such a dense material at meaningful sample length scales (sample in the order of 300-400mm diameter) confirmed that critical data on individual particle rotations could be obtained in acceptable time scales using the custom hutch's curved linear array and 450kV source. The results are now being taken forward to validate DEM (discrete element method) simulations of ballast deformation.

More information and images can be found at http://www.soton.ac.uk/muvis/



3D CT rendering clearly illustrates the fibre orientation and damage that are observed in laminates.



Fatigue damage in high strength Al-alloys, as used in high pressure gas containment systems.