MICRO-CT SCANNING

University's Micro-CT Facility Reaches Grant Goals

Figure 1. Nikon Metrology XT H 225 ST 225 kV micro-CT system at U of A.

An advanced XT H 225 ST microfocus computed tomography (micro-CT) imaging system from Nikon Metrology (www.nikonmetrology.com) has been installed at the University of Arkansas (U of A - www.uark.edu) to enable two- and three-dimensional, non-destructive study of the inside as well as the outside of a wide variety of objects, including historical artifacts and manufactured materials as well as geological and biological specimens.

The scanner was installed in April 2018, following the university's receipt of a US National Science Foundation grant in the fall of 2017 to help purchase a CT scanner and to cover further equipment and running costs for three years. The facility now has more than 100 paying users from 30 different institutions including the U of A itself using the drop-off and unassisted scanning services. Remarkably, these users have collectively secured over $4 million in additional grant funding for their own projects by taking advantage of the micro-CT service.

Project inception

It was back in 2015 that Dr Claire Terhune in the anthropology department at U of A and her colleagues decided that acquisition of an X-ray CT system was the way to progress the research being carried out by the university's faculties. Before submitting the grant proposal, she and the another lead investigator, Dr Paul Gignac from the Oklahoma State University Center for Health Sciences in Tulsa, OK, reviewed equipment from several suppliers.

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Nikon Metrology equipment was selected due to the wide choice of X-ray sources and target materials, which offer more flexibility and versatility as well as higher resolution than other systems on the market. It was an important issue to those intending to use the system, as at one end of the scale they want to examine a microchip or an insect and then soon afterwards a large fossil or ceramic artifact might be under examination.

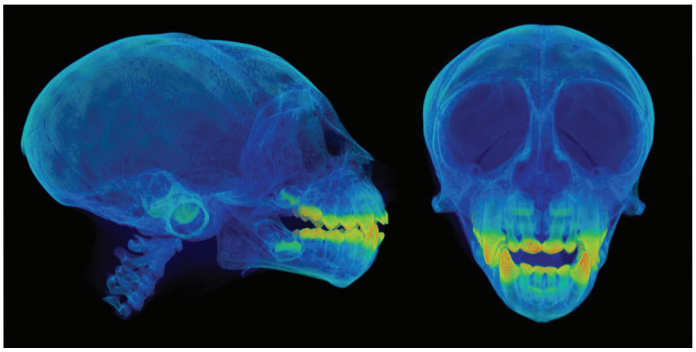

Figure 2. Juvenile capuchin monkey head. 3D Rendering produced in Avizo by Dr. Claire Terhune.

During the initial investigation, contact was made with the Wits Evolutionary Studies Institute in Johannesburg, South Africa, where a Nikon Metrology XT H 320 dual-source micro-CT system has been in operation for many years. One well publicized project that harnessed the equipment's high spatial resolution involved detailed radiographic analysis of the fossilized cranium of the famous Taung Child, the first hominin to show both human and ape-like characteristics.

Exchangeable X-ray targets

One of the main advantages of Nikon Metrology's open-tube micro-CT system, apart from the small focal spot size, is the ability to quickly exchange the tungsten target that electrons hit to generate X-rays. Additionally, Nikon Metrology's rotating target is unique outside medical CT scanning. It delivers very high contrast images by increasing the X-ray flux and hence the power of the X-rays produced, while maintaining a small focal spot size. This enables denser samples to be penetrated at very high resolution.

Manon Wilson, the lead technician responsible for using the XT H 225 ST at the U of A advised that the rotating target, with a focal spot size down to 10 microns, is in place most of the time. It provides very crisp images and frequently reduces the time needed to scan objects, saving researchers money and allowing them to afford more scanning time. If focal spot size better than 10 microns is required, a static target replaces the rotating version to provide imaging from 10 to 3 microns, or the transmission target gives a spot size down to 1 micron.

MICRO facility

The X-ray scanner is operated and managed by the MicroCT Imaging Center for Research and Outreach (MICRO - https://micro.uark.edu), established in 2018 and housed in the U of A's Center for Advanced Spatial Technologies (CAST), which is dedicated to applying geospatial techniques in research, teaching and service. The MICRO facility is led by Dr Terhune (Anthropology), while the project's co-principal investigators are Drs George Sabo (Arkansas Archeological Survey) and Wenchao Zhou (Mechanical Engineering) from the U of A, as well as Drs Paul Gignac and Haley O'Brien (Anatomy and Cell Biology) from the from the Oklahoma State University Center for Health Sciences.

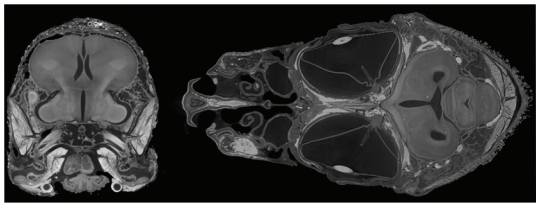

Figure 3. A bird head prepared using diceCT by Dr. Paul Gignac. The iodine enhances visualization of soft tissues

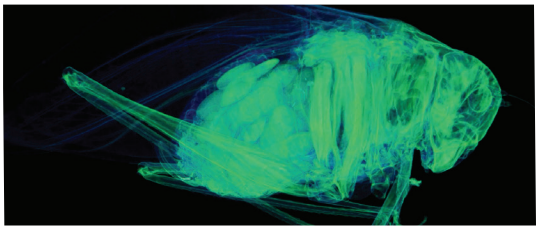

Figure 4. A low-density scan of a katydid showing egg sacs in its abdomen. Avizo rendering by Manon Wilson.

Micro-CT Scanning

The two heaviest users at the U of A are the anthropology and biomedical engineering departments. In anthropology, the micro-CT facility has helped support research examining the anatomy of the human and primate skull and it has helped one of the university's researchers to identify a new species of ancient monkey by CT scanning a fossilized tooth.

Extensive use is made of diffusible iodine-based contrast enhancement (diceCT) for biological specimens, which allows soft tissue to be observed in addition to higher density materials such as bone and is invaluable in comparative anatomical studies. Drs. O'Brien and Gignac rely heavily on diceCT and extensively use the equipment to analyse the comparative anatomy of a wide array of vertebrate species and to understand 3D anatomy of the brain, among other topics.

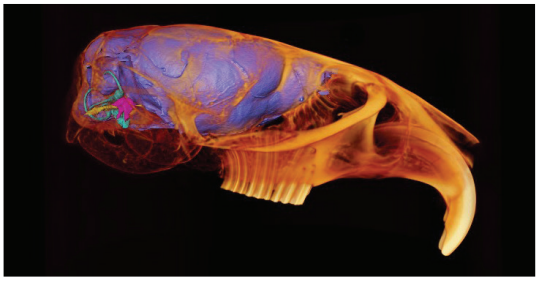

Figure 5. Vole skull (orange) 3D rendering to show the braincase (purple) and inner ear features (blue, pink and yellow). 3D rendering performed by Avizo in Dr. Haley O'Brien

Another major user of the facility on U of A's Fayetteville campus is mechanical engineering. One research project being carried out by Dr. Zhou is to assess best techniques for additive manufacturing by investigating the internal properties of 3D printed objects. Engineered materials with applications in next-generation power sources is another focus of attention. The micro-CT is also used for research and outreach activities by scientists and students across northwest Arkansas, central and eastern Oklahoma, southern Missouri and south-eastern Kansas, and the facility highlights interesting scans and research on its social media accounts on Twitter and Facebook.

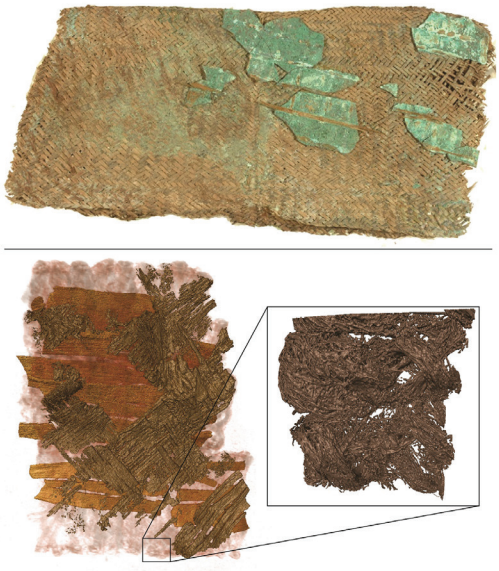

Figure 6. A test scan generated by Nikon Metrology prior to delivery of the micro-CT system to U of A. It shows a photograph of woven box lid with copper plating (top) and 3D reconstruction of a cord-wrapped basket fragment found at Spiro Mounds, a Caddo archaeological site in eastern Oklahoma.

Conclusion

Scanning by micro-CT is among the most effective technologies for capturing data from the inside as well as the outside of specimens non-destructively, quickly and at a reasonable cost. It is also accurate enough to measure features precisely. The range of applications is vast, from the study of fossils and archaeological artifacts to the analysis and measurement of additively manufactured parts, safety-critical aerospace components, welded assemblies, biomedically engineered bone and many other items – basically any object 20 inches in diameter or smaller and weighing up to 110 pounds.

Figure 7. MICRO also scans everyday objects such as this banana for social media outreach. 3D Avizo rendering by Dr. Haley O'Brien.

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