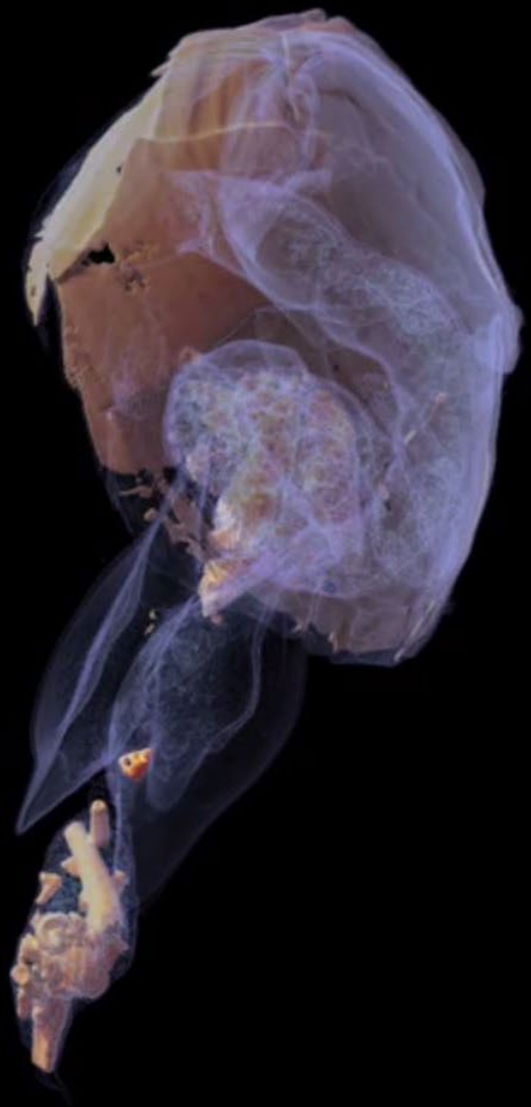
National Imaging Facility

National Imaging Facility Quarterly Newsletter Issue One 2018



Headshield Slug (Philine sp.) micro-CT scan shows internal shell and stomach of probable new species found in Asia © Australian Museum

Imaging Data collected by Dr. Karine Mardon - Centre for Advanced Imaging, The University of Queensland

National Imaging Facility

In This Issue

CEO's Message

I trust that you enjoy reading this Newsletter as much as the NIF team enjoy putting it together. It is not designed as a source of the latest scientific breakthrough, although it always points to great science. Each article is chosen to highlight an aspect of what extra opportunity NIF brings to the scientific community, and how NIF can support your research.

NIF's mandate is to provide world-class infrastructure, and to give you, as the research user, the best data possible and the best possible experience. Managing data is time-consuming, often not exciting, but essential to delivering quality, reproducible outcomes, and greatest impact. So NIF invests heavily in developing tools, platforms and analysis workflows, to relieve our users of the burden of establishing your own pipelines. NIF is committed to instrument to repository data management, whilst giving you, the user, total control over your data.

The NIF partners are also committed to providing access to the wider scientific community, and particularly researchers who are not traditionally part of the imaging community. So two projects described come from researchers who may not have previously considered imaging as a research tool. Both projects could have important implications for climate research, supporting research about our natural history and environmental effects on plants.

Have you considered how imaging may add an extra dimension and added impact to your project? We always love to get feedback, and are happy to answer any questions about these articles, or your needs for an imaging component to your research.

Professor Graham Galloway
Chief Executive Officer

National Imaging Facility

RESEARCH PROJECT

Dicom2Cloud - Developing a Graphical User Interface for Anonymizing and Uploading Clinical Brain Scans to an Image Processing Cloud Instance

Modern image processing algorithms aim to have clinical impact and help diagnose a variety of diseases, such as Multiple sclerosis, Parkinson, and neurodegeneration. However, many state-of-the-art post-processing techniques are not applied in a clinical setting, because the software developed by scientists is difficult to use, often operating-system specific, and might require extensive hardware resources. This limits the translation of research into clinical applications. One potential solution would be to upload the medical data to a cloud instance where all tools are installed and sufficient computational resources are available. The problem, however, is that medical data contains sensitive information that cannot be easily removed, such as facial features in magnetic resonance imaging data of the brain. During the last Health-Hack event held in Brisbane (https://www.healthhack.com.au/), a team of enthusiastic developers (Saskia Bollmann, Isaac Lenton, Aswin Narayanan, Elizabeth Cooper-Williams, and Yixia Peng) led by National Imaging Facility (NIF) Fellow, Dr Steffen Bollmann, approached this problem and developed Dicom2Cloud - a graphical user interface for Windows, Linux and Mac OS that can read DICOM data, remove facial features, and upload this data to cloud platforms such as Amazon AWS and Google cloud, where a wide range of processing algorithms can be applied.

Dicom2Cloud was developed as a platform-independent toolchain with a Python-based graphical user interface (GUI) (Fig. 1). The implementation is open source and available on GitHub (https://github.com/CAIsr/dicom2cloud). The application (Fig. 2) has three major processing steps: (i) file selection, (ii) anonymization, and (iii) upload, processing and download via a cloud instance. In detail, the File Panel (Fig. 1B) is used to select a directory containing DICOM files, from which the DICOM header information is read and an image series is selected for processing. The Process Panel (Fig. 1C) allows the user to select the required cloud service and processing pipeline. Each image series is first anonymized using the MINC toolkit packaged inside a local Docker container build using Neurodocker. In particular, we use dcm2mnc to convert the DICOM files into the MNC format, and mincanon to remove header information, such as scan date and time, name, date of birth and information not critical for the image.

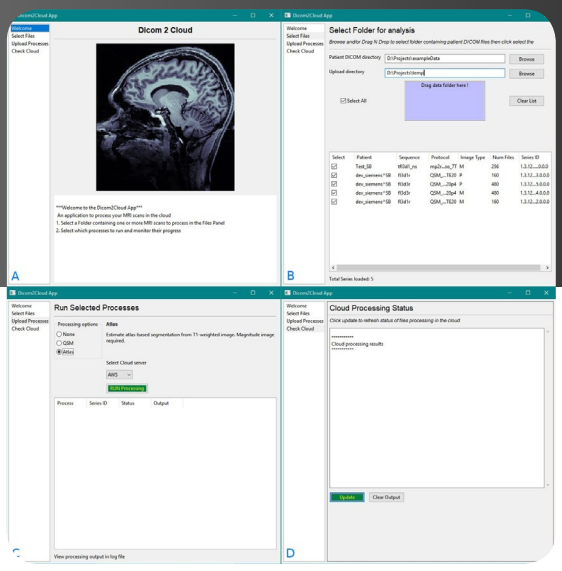


Figure 1 - Components of Dicom2Cloud GUI: A) Application overview, provides overview of the application and information about updates, B) File Panel, allows selection of DICOM datasets, C) Process Panel, allows selection of cloud service and type of processing, D) Cloud Panel, monitors submitted jobs and downloads processed files from the cloud.

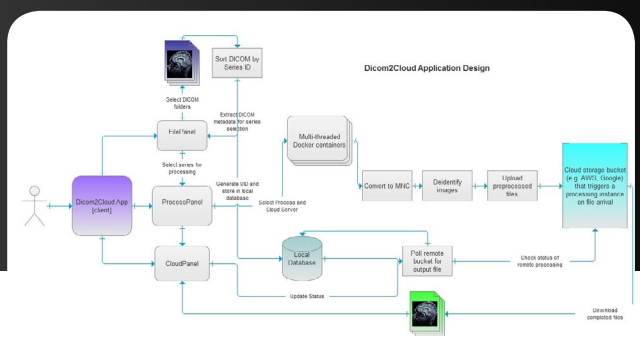


Figure 2 – Dicom2Cloud's application design overview. The application consists of 3 panels that are used to select files, control the pre-processing and pipeline selection and deliver information about the processing status in the cloud instance.

However, the facial features remain in the data and the patient could potentially be re-identified. We therefore apply a de-facing pipeline that robustly removes facial features without introducing artificial edges (Fig. 3), which otherwise would have negative effects on registration algorithms. Next, the fully de-identified image is transferred to cloud storage where an image processing pipeline is automatically started on file arrival. Finally, the resulting output files are downloaded back to the client and re-associated with the patient ID. The Cloud Panel (Fig. 1D), allows the user to check the status of files sent for processing in the cloud.

The design of Dicom2Cloud would also allow local docker images to perform the full processing of data for less intensive operations and therefore, could even be used without a cloud backend. The team is currently developing pipelines for running a brain segmentation using FreeSurfer and the computation of quantitative susceptibility maps for the first release of the software and is looking for beta testers to test these pipelines. The team is currently also seeking funding to pay for cloud computing costs that would allow to offer the image processing cloud backend free of charge for users.

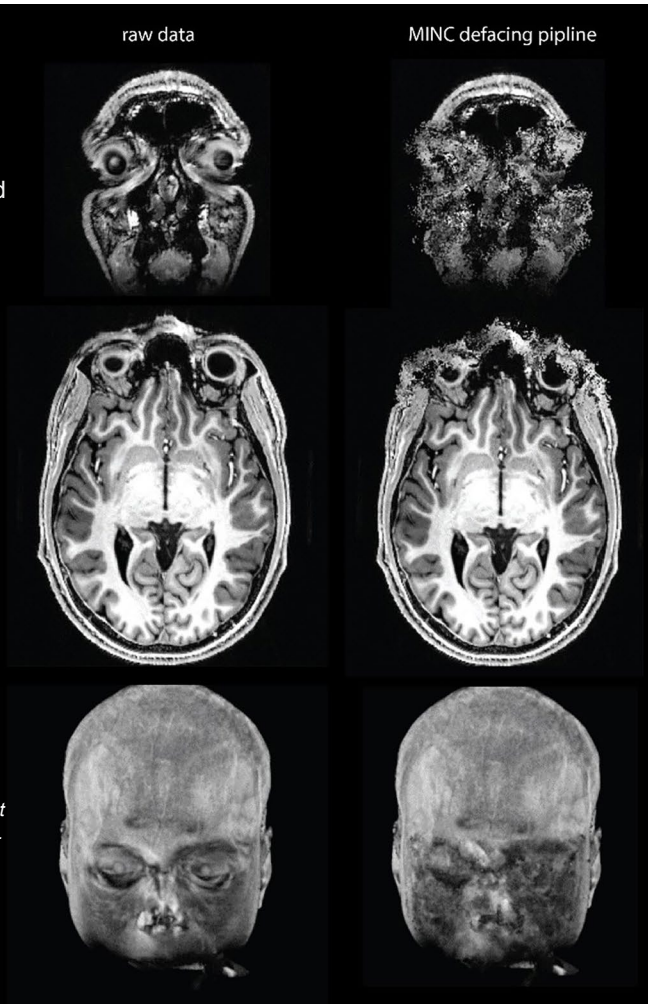


Figure 3 – This figure illustrates the result of the de-facing pipeline that was implemented. The goal is to remove facial features without introducing artificial edges that could cause problems in later steps.

For more details on the study, please contact Dr Steffen Bollman (steffen.bollmann@cai.uq.edu.au).

Dr Steffen Bollmann, NIF Fellow, is a post doctoral research fellow at the Centre for Advanced Imaging, UQ. He obtained a bachelor's degree in science / biomedical engineering at the Ilmenau University of Technology, followed by a Masters degree in biomedical engineering & bioelectromagnetism. Following this, Steffen completed a PhD investigating multimodal imaging in ADHD children, adolescents and adults at the Neuroscience Centre Zurich and the Centre for MR-research, University Children's Hospital Zurich. Steffen joined the Centre for Advanced Imaging, University of Queensland, in October 2014, where he is applying his expertise in multimodal imaging in the group of A/Prof. Markus Barth combining high resolution quantitative imaging (susceptibility, T1, T2), functional MRI (fMRI), and electroencephalography (EEG) with the goal to understand the relationship between functional networks and to work towards identifying early biomarkers for neurodegenerative diseases. Exploiting the high signal levels of ultra-high field 7 Tesla MRI he aims to investigate and quantify disease processes on a single subject level.*

National Network of Trusted Data Repositories

National Cross-Capability Project

During 2017 the National Imaging Facility (NIF) nodes at the University of Western Australia (UWA), University of Queensland (UQ), University of New South Wales (UNSW) and Monash University collaborated on a national project to enhance the quality, durability and reliability of data generated by NIF. The Project, *Delivering durable, reliable, high-quality image data*, was jointly funded by the Australian National Data Service (ANDS) and Research Data Services (RDS). It was motivated both by NIF's desire to enhance the quality of the data associated with the use of its facilities, and the desire of ANDS/RDS to facilitate the establishment of Trusted Data Repositories that enable access to data for at least 10 years and includes metadata that documents both the quality of the data and its provenance.

- *Quality pertains to a NIF user's expectation that an animal, plant or material can be scanned and from that data reliable outcomes/ characterisations can be obtained (e.g. signal, volume, morphology) over time and across NIF sites.*
- *Durability refers to guaranteed long-term availability of the data.*
- *Reliability means that the data is useful for future researchers, i.e. stored in one or more open data formats and with sufficient evidential metadata.*

The scope of the Project was limited to MRI data with the understanding that the developed requirements and trusted data repository services could be adapted to, or serve as a basis for other instruments/modalities.

The key outcomes from the Project include:

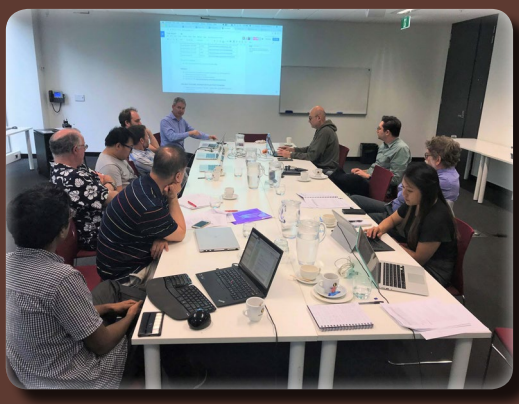
1. The *NIF agreed process for acquiring trusted data (NAP)* - Lists the requirements that must be satisfied to obtain high-quality data, i.e. NIF-certified data, suitable for ingestion in a NIF trusted data repository service. They cover provisioning of a unique instrument identifier, instrument registration with Research Data Australia (https://researchdata.ands.org.au), Quality Control (QC), quality assurance measures, requisite metadata (including cross-reference to the QC data), the process by which data is moved from the instrument to the digital repository service and the format(s) of the data.

2. The *NIF requirements for a trusted data repository service* - Provides a platform-agnostic checklist of requirements that a basic NIF trusted data repository service should satisfy, including: identification of data by a unique Project identifier, ingestion of data from NIF-compliant instruments, authentication via the Australian Access Federation (https://aaf.edu.au), interoperability and easy deployment across NIF nodes.

3. Implementations of trusted data repository services for two exemplars:
    - Preclinical MRI data (with mouse brain data as an example) acquired across three NIF nodes—UNSW, UQ and UWA—using a Bruker BioSpec 9.4T MRI. The services have been implemented using the open source MyTardis/ ImageTrove (https://www.mytardis.org) platform.
    - Clinical ataxia MRI data acquired using a Siemens Skyra 3T MRI scanner in support of a Monash-proposed International Ataxia Imaging Repository (IAIR). The service has been Implemented using the open source XNAT (https://www.xnat.org) platform.

    Software developed to support the implementation of the repository services includes: Docker (https://www.docker.com) Compose scripts to permit easy deployment at differents sites, client-side scripts for uploading NIF-certified data to ImageTrove/MyTardis and an XNAT plugin for uploading non-DICOM files.

4. Assessments of the resulting trusted data repository services against a relevant international metric, the CoreTrustSeal (https://www.coretrustseal.org) Core Trustworthy Data Repositories Requirements.



Above: The team met throughout the year to tackle the issue of long term reliable imaging data storage and access.

Dr. Andrew Mehnert, NIF Informatics Fellow is the Project manager and UWA lead

Andrew is Senior Lecturer in Data Management, Analysis and Visualisation at the Centre for Microscopy, Characterisation and Analysis (CMCA) at the University of Western Australia (UWA). His position is jointly funded by NIF and the Australian Microscopy & Microanalysis Research Facility (AMMRF).

For NIF users and the broader imaging research community the benefits and impact of this Project include:

- Reliable and durable access to data
- Improved reliability of research outputs and the provenance associated with it
- Making NIF data more FAIR (Findable, Accessible, Interoperable, Reusable - https://www.ands.org.au/working-with-data/the-fair-data-principles)
- Easier linkages between publications and data
- Stronger research partnerships

For research institutions they include:

- Enhanced reputation management
- A means by which to comply with the Australian Code for the Responsible Conduct of Research
- Enhanced ability to engage in multi-centre imaging research projects

For NIF they include:

- Improved data quality
- Improved international reputation
- The ability to run multi-centre trials

The transition plan post-funding includes: maintenance of existing services for 10 years; the integration of additional instruments; creation of a project web portal; planned new national and international service deployments; refinements and improvements; and CoreTrustSeal certification.

Project documents have been archived in the NIF Customer Relationship Management (CRM) system (accessible by NIF staff). Project software is hosted on GitHub and is freely available for download here: https://github.com/NIF-au/TDR. For further information please contact either the national Project Manager (andrew.mehnert@uwa.edu.au) or NIF (admin@anif.org.au).

Project Manager and UWA lead: Andrew Mehnert (NIF Informatics Fellow, Centre for Microscopy, Characterisation and Analysis)
NIF lead - Graham Galloway (Chief Executive Officer, NIF)
UQ lead - Andrew Janke (NIF Informatics Fellow, Centre for Advanced Imaging)
UNSW lead - Marco Gruwel (Senior Research Associate, Mark Wainwright Analytical Centre)
Monash lead - Wojtek Goscinski (Associate Director, Monash eResearch Centre)

A trusted data repository service is essential for sharing data and ensures that project data created and used by researchers is "managed, curated, and archived in such a way to preserve the initial investment in collecting them" and that the data "remain useful and meaningful into the future" (https://www.coretrustseal.org).

MRI Studies of Freezing in Cold Hardy Plants

Freezing is one of the extreme environmental factors affecting plants. Cold hardy plants have evolved a variety of complex strategies to control water behaviour under freezing conditions. These include strategies to survive water deficit and subfreezing temperatures that could cause lethal intracellular freezing of water. Many plants spontaneously reduce their water content during formation of seeds in a controlled manner without losing the integrity of the cells or vice versa during rehydration of the seeds.

Some mechanisms involve special compounds for controlling water behaviour (e.g., supercooling stabilizing compounds, SSC; anti-nucleation compounds, ANC; and ice nucleation agents, INA) and regulate phase changes of water (water to gas, water to ice or vice versa). SSCs include some flavonoids, polyphenols, and anthocyanins. ANCs include SSCs plus some compounds specific to each ice nucleator. INAs include some proteins and small organic substances. These compounds may possibly regulate the behaviour of aqueous solutes including the avoidance of unwanted precipitation/bubble formation and promotion of preferential precipitation/aeration both in solution and on surrounding components such as membranes and cell walls (gel to sol or vice versa).

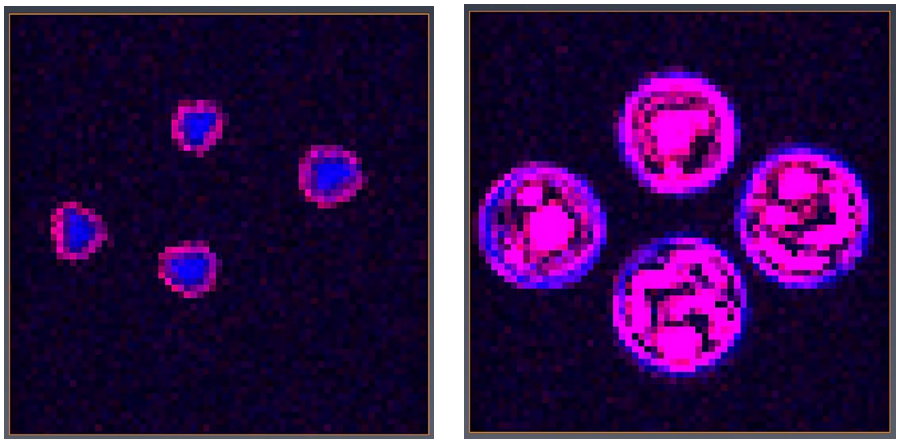


Figure 1 (left): Colour-coded axial cross sections of Fagus (left) stems/(right) leaf buds constructed from a series of ^{1}H magnetic resonance 3D datasets conducted at various temperatures of 4 Fagus leaf buds. The field of view is 9 × 9 mm with pixel dimensions of 134 × 134 µm. Red shows "high temperature" freezing (> -14 °C) and blue shows tissues that didn't freeze, even at -19.5 °C. (left) The blue interior of the stem (pith) remains unfrozen. (right) The exterior (the surface of bud scales) in this case remains unfrozen.

The distribution of water throughout plant tissues can be visualised using MRI. In an MRI scan, a radiofrequency pulse excites the aggregate nuclear magnetisation giving it a transverse component which is then acquired as a signal and processed to give an image. The transverse magnetisation disappears at a rate quantified by the T_2 relaxation time. Typically, after excitation of the magnetisation, there is a delay of a few milliseconds before acquisition of the signal. Ice water has a significantly lower transverse relaxation time than liquid water and so the signal from ice vanishes giving an image that only shows the liquid water. The freezing of plant tissues can be studied by conducting a series of experiments at different temperatures. At any particular temperature only the unfrozen water in tissues will contribute to the image. The sequence of images can then be combined to show freezing behaviour of the tissues.

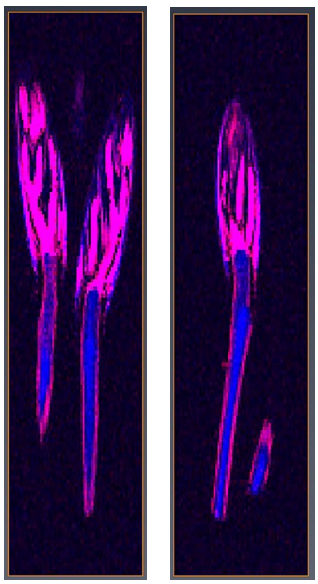
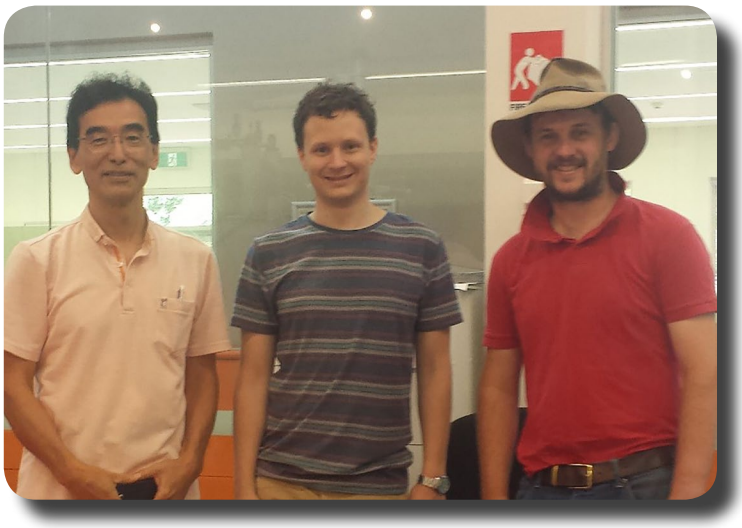


Figure 2 (left): Another figure created from the same 3D dataset showing the unfrozen interior (pith) of the Fagus stem and the unfrozen exterior (the surface of bud scales) of the leaf bud. The field of view is 9 × 37.5 mm with pixel dimensions of 134 × 250 µm.

Figure 3 (left):Fagus leaf buds.

The colour-coded images (figures 1 and 2) of the Fagus leaf bud (a species of Japanese mountain vegetation, figures 3 and 4) were constructed from fourteen experiments conducted at temperatures ranging from 1 °C to -19.5 °C (specifically 274, 270, 268, 266, 264, 261, 259, 258, 257, 256, 255.5, 255, 254.5, 254 K). The plant was given an hour to equilibrate at each temperature prior to scanning using a gradient echo sequence to produce a 3D dataset with resolution 134 × 134 × 250 µm. The temperature was then lowered and the procedure repeated. Subtracting an image acquired at a lower temperature from an image acquired at a higher temperature gives an image showing the tissues that froze between those two temperatures – if a tissue doesn't freeze then subtracting mostly cancels the tissue from the image, whereas if the tissue does freeze it is absent from the lower temperature image and is therefore not cancelled by the subtraction. In this way, images of the tissues that froze between each of the successive temperatures in the list above can be created. The images in figures 1 and 2 were created by colour coding these "difference images" red for freezing that occurs at higher temperatures and blue for freezing that occurs at lower temperatures.

Figure 4 (above): Fagus in its natural habitat.



The interior of the stem and exterior of the bud did not freeze at all, even at -19.5 °C – these tissues appear blue in the images. From differential thermal analysis and MRI there are three different freezing behaviours seen in different tissues with freezing events occurring at warmer temperatures than -11 °C, between -11 and -17 °C and lower than -17 °C. Similar experiments have been conducted at the Western Sydney University Node of NIF on Azalea flower buds and Cornus species (C. officinalis, C. japonicam, C. florida). Another set of experiments examines where and how freezing starts at set temperatures; these experiments additionally include blueberry and forsythia stems.

Interestingly, drought and freezing lead to similar behaviours of water at the plant cell level. Under freezing stress, most typically, the cells undergo extracellular freezing where the primary freezing is initiated in the intercellular spaces and the cell water (>70%) migrates to the extracellular spaces during cooling to -7 °C, which results in extreme dehydration of the cells during further cooling.

MRI is proving to be a powerful tool for studying freezing of cold hardy plants and identifying tissues containing powerful freeze regulating compounds which may be valuable resources for food industries, clinical use, cryopreservation of embryos and oocytes for IVF, endangered species, etc.

Figure 5 (left): Dr Masaya Ishikawa; WSU NIF Fellow, Dr Tim Stait-Gardner; and WSU Biomedical Magnetic Resonance Facility Manager, Dr Scott Willis.

Collaborators

Biomedical Magnetic Resonance Facility, Western Sydney University node of National Imaging Facility

Tokyo University of Science, Noda, Chiba, Japan

The University of Tokyo

Imaging Uncovers Internal Structure of Australian Treasures

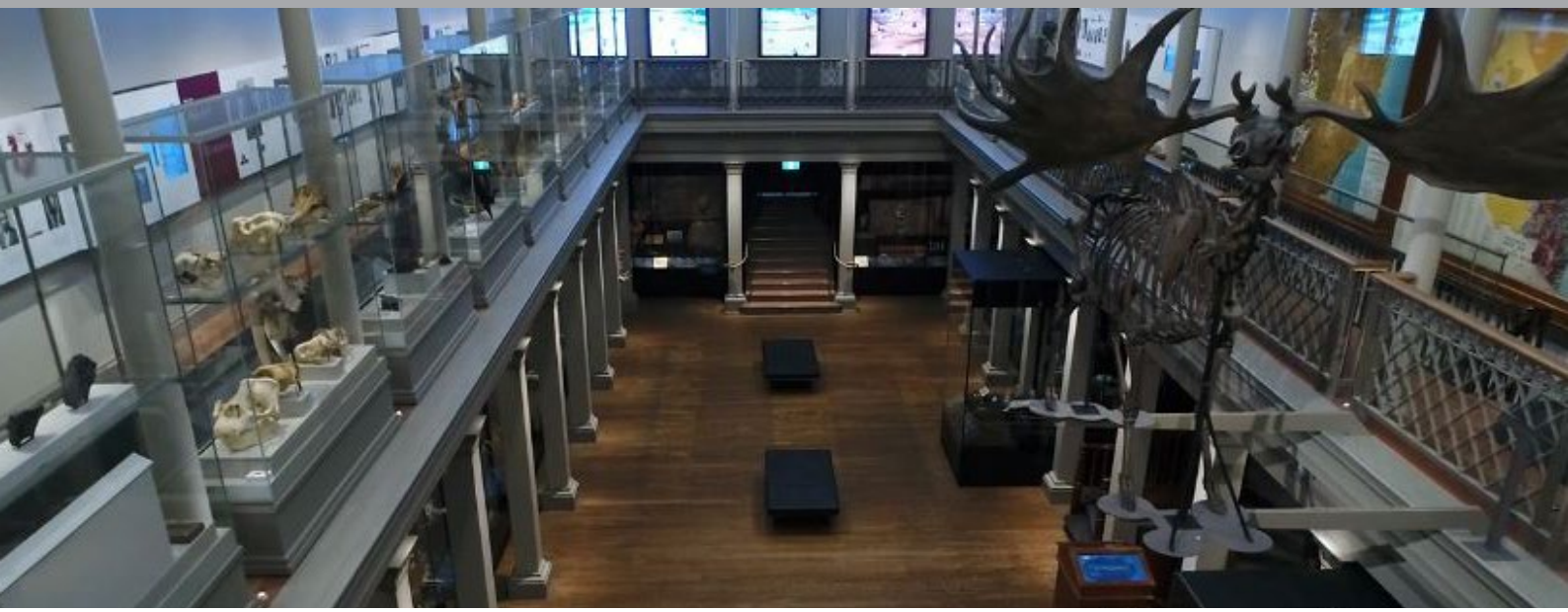
News

Micro-CT imaging data collected by NIF Fellow, Dr. Karine Mardon, using the Inveon PET-CT scanner at the Centre for Advanced Imaging (CAI), the University of Queensland node of NIF, has been transformed into an interactive display as part of the 200 treasures exhibition at the Australian Museum's newly restored Long Gallery (now Westpac Gallery).

The data has been reconstructed to create a multimedia, interactive exhibit where visitors can see a 3D model of the internal structures of several specimens.

The Westpac Gallery 200 Treasures, which will be a permanent installation, features 100 invaluable treasures from the Australian Museum collection, and the stories of 100 people who have had a profound influence on Australian history.

The gallery has a rich history, as the first gallery in Australia's first museum. The 19th century theatre has been extensively restored over the past two years to preserve and adapt the space. While respecting the historical significance of the gallery, it has embraced a modern spirit reflecting the museum's current and future collections.



The Museum has been experimenting with CT to view internal structures of a specimens without the need for dissection. The Headshield Slug micro-CT was able to show the internal shell and entire digestive tract - including the creature's last meal! AMRI scientists are using the scans to collect and interpret data from a number of specimens.

Acknowledgements
Micro-CT data collected at the Centre for Advanced Imaging, The University of Queensland
Multimedia display in the Westpac Long Gallery developed by the interactive design company Holly.

Article, written by Nina Moore, is available at https://cai.centre.uq.edu.au/article/2017/12/imaging-data-treasured-asset

Long Eared Bat multimedia display. Image © Australian Museum

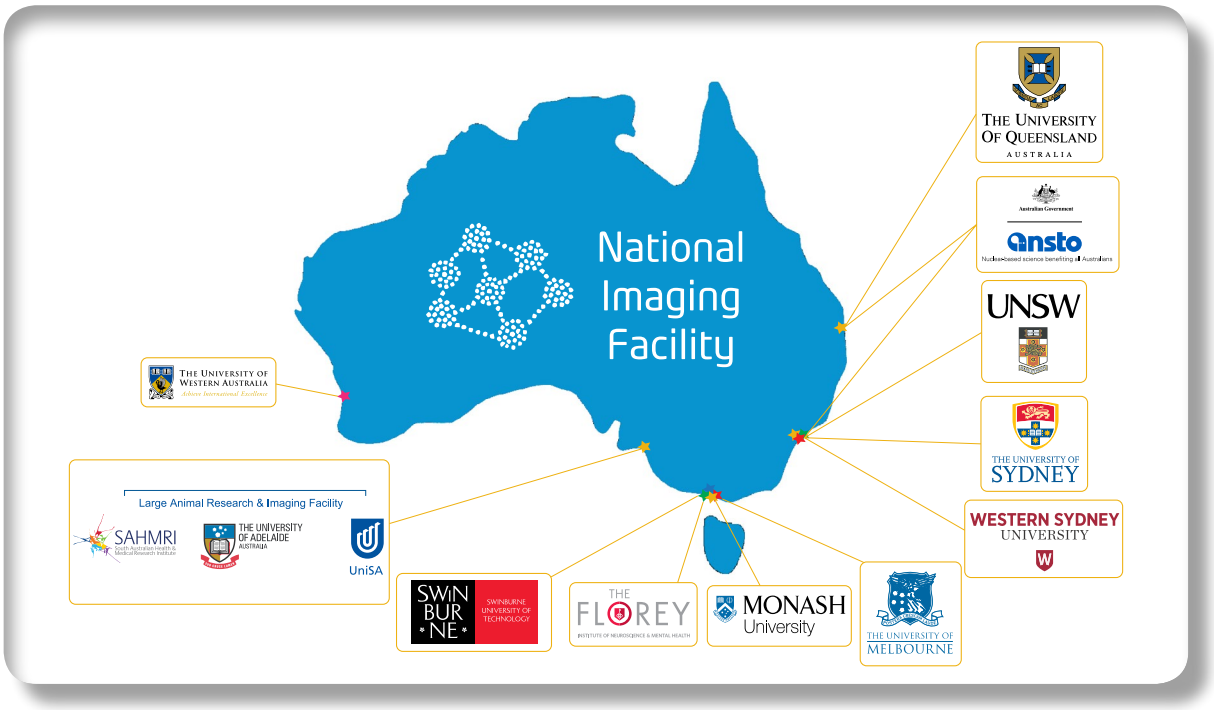
Headshield Slug multimedia display. Image © Australian Museum

Impact

Australian research communities are well familiar with the word *Impact* and the recent emphasis and requirement for identifying and demonstrating research impact. Until recently, the evaluation of research has focused largely on publications, patents, and grants. Much less attention was paid to the relative impact beyond outputs and outcomes. The move towards impact measurement encourages engagement beyond a particular academic discipline and awareness of the interests and needs of the people that fund research. It also focuses effort on clearly articulating the many ways in which investments in research deliver benefits for society.

In response to this requirement and to demonstrate the impact of research infrastructure, the National Collaborative Research Infrastructure Strategy (NCRIS) capabilities have initiated a working group to develop and define metric that indicate the Impact of NCRIS at program level. The group holds regular teleconference meetings and had a face-to-face workshop in Canberra, February this year. The main objective of the workshop and meetings is to come to a common view of the Impact Pathway, which can be used by individual capabilities. Following these efforts, NIF has reviewed its major performance indicators to align with the Impact Framework and will continue to work closely with other NCRIS capabilities to refine them.

Another initiative of the NCRIS capabilities was to establish *'The NCRIS Communications Group'* early 2017 for the purpose of collaborating and sharing ideas and resources between the NCRIS funded projects, as well as the essential enabling infrastructure services of AARNet and AAF. The group, which comprises of Communication and Engagement Managers of NCRIS capabilities, has developed NCRIS Network website. The website exposes the value of NCRIS capabilities and provides a central hub for stories and successes of the projects. Visit www.ncris-network.org.au to learn more about the *Impact* of NCRIS capabilities.



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