CoSeC Grand Challenges

The Collaborative Computational Project in Tomographic Imaging (CCPi)

The CCPi Grand Challenge aims to transform X-ray CT from an inspection tool into a quantitative platform for research and industrial verification. It focuses on scaling advanced techniques like hyperspectral and in-situ CT for high-throughput, real-time analysis, integrating multimodal imaging (e.g., neutron, muon, SAR)

The Community

CCPi TOMOGRAPHIC IMAGING

www.ccpi.ac.uk

The Collaborative Computational Project in Tomographic Imaging (CCPi) supports the UK non-clinical computed tomography (CT) community by delivering open-source software and expert training to enable researchers to extract higher-quality results from CT data.

In 2018 CCPi helped shape the EPSRC X-Ray Roadmap, which identified key priorities for advancing the field. These included lowering barriers to entry for new users—both in terms of hardware and software—providing training across all experience levels and enabling scientific progress through improvements in temporal and spatial resolution. The roadmap also highlighted the need for new imaging modalities, such as phase contrast, spectral (colour) imaging, and crystallography, as well as the development of advanced in-situ and in-operando techniques.

Since then, CCPi has delivered the Core Imaging Library (CIL) for processing and reconstruction across lab and synchrotron sources; including tools for standard, in-situ and hyperspectral CT. CCPi has provided extensive training through conferences, user meetings and online resources. A new user survey will be made in 2025/26 to ensure that X-ray CT software developments align with the emerging needs through the updating of the CT Roadmap.

The Challenge

Tackling an increasing volume of image datasets and sub-optimal data, leveraging AI and encapsulating Rich Tomography

CT is an invaluable tool for nondestructive testing widely used in industry; it enables both structural and chemical measurements and allows the study of materials properties in situ. Hyperspectral and insitu CT have already been demonstrated at research scale, but the grand challenge lies in deploying these capabilities at industrial scale with high throughput and reliability. Its evolution toward hyperspectral, highspeed, and multimodal capabilities will be critical for addressing global challenges in energy, sustainability, and resilience.

For **energy solutions**, CT must track structural and chemical changes in working batteries capturing phase evolution, porosity, and catalyst distribution under realistic conditions. These insights are vital for improving materials, durability, and scalable manufacturing to meet netzero goals.

In **harsh environments** such as fusion reactors, advanced engines, and nuclear systems, CT should reveal degradation mechanisms—irradiation, corrosion, embrittlement—under temperature and load, while using spectral contrast to monitor chemistry as coatings and surfaces are engineered for extreme conditions.

For **lowcarbon construction**, CT can quantify hydration, microcracking, carbonation, and recyclability in next generation cements, providing feedback to cut emissions and enable circularity.

Across all domains, CT must evolve to deliver high-throughput workflows, integrate multimodal data and ensure reproducible analytics so that massive 4D datasets become actionable insights for process optimization and real-time decision-making in manufacturing and production environments.

Future imaging must integrate multimodal approaches—combining with other sources such as neutron, muons, emission imaging, Synthetic Aperture Radiography (SAR), , and other techniques with—to address scenarios where X-rays cannot penetrate or full rotation is impossible. The challenge is to develop unified workflows and reconstruction algorithms that fuse sparse, physics-limited data into coherent, quantitative models. This integration will enable imaging of large, dense, or hazardous objects such as nuclear waste, aerospace components, and critical infrastructure, providing actionable insights for design validation, safety assurance, and production quality control in extreme environments.

The Solution

A vast suite of transformative tools, solutions and techniques that will allow researchers to accelerate tasks and maintain high performance

Software is central to unlocking the next generation of CT capabilities, and CCPi will lead by:

- Developing advanced processing pipelines for hyperspectral, in-situ, and multi-modal CT, enabling researchers and industry to extract quantitative structural and chemical information under realistic operating conditions.
- Optimizing performance for scale, creating algorithms and workflows that handle datasets efficiently
- Training the next generation of CT practitioners, ensuring skills in advanced imaging, data analytics, and AI-driven interpretation to support industrial adoption.

Grand Challenges

- Building reproducible, automated workflows that transform CT from a research tool into a production-ready platform for process optimization, predictive maintenance, and digital twin integration.

The Outcome

A quantitative platform for research and industrial verification

CT will evolve from a powerful inspection tool into a **quantitative platform for research and industrial verification**. It will provide both structural and chemical information in real time, enabling scientists to study materials under realistic conditions and engineers to validate components with greater confidence. High-speed, multi-modal CT will support **faster development cycles**, reduce defects, and improve reliability in manufacturing. This will accelerate innovation in energy technologies, advanced materials, and sustainable construction.

More Information

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