Review report on PhD thesis

Faculty: Central European Institute of Technology, Brno University of Technology

Academic year: 2025/2026

Student: Ing. Jakub Lázňovský

Doctoral study program: Advanced Materials and Nanosciences

Supervisor: Prof. Ing. Jozef Kaiser, Ph.D.

Reviewer: Doc. Ing. Ladislav Pína, DrSc.

PhD thesis title: Material evaluation and characterisation by X-ray computed tomography

Topicality of doctoral thesis:

The presented dissertation thesis addresses an important and current topic in the field of X-ray computed tomography (CT) for quantitative evaluation and characterisation of materials. The topic is highly relevant, as CT is becoming a key tool for non-destructive analysis both in materials science and life sciences. The thesis successfully bridges these domains by presenting methodological developments applicable to both biological research and additive manufacturing materials analyses.

The focus on transforming CT from a qualitative imaging method into a quantitative analytical tool represents a valuable and challenging scientific objective. The author successfully connects developments in imaging physics, algorithmic processing, and practical applications. The topic aligns well with the current global trends in digital material evaluation and advanced imaging techniques.

Meeting the goals set:

The objectives of the dissertation were clearly defined and have been fully accomplished. The research focused on the development and optimisation of X-ray computed tomography methodologies for the quantitative evaluation and characterisation of materials. Particular attention was devoted to establishing reliable workflows for data acquisition, calibration, segmentation, and quantitative analysis, and to demonstrating their applicability through representative case studies involving both biological and engineering materials.

These aims were systematically implemented through several detailed studies, including mineral density estimation in bones, quantitative evaluation of spinal fusion, automated morphometric analysis of mouse skulls, developmental mapping of *Xenopus laevis*, and CT-based assessment of powder and component quality in additive manufacturing. The results clearly demonstrate that the author has successfully met all objectives of the dissertation and achieved them with a high degree of methodological rigour, reproducibility, and experimental precision.

Problem solving and dissertation results:

The dissertation presents original and methodologically advanced solutions for the interpretation and analysis of CT data. Among the key outcomes are a validated method for the quantitative calibration of CT measurements to hydroxyapatite standards, enabling precise characterisation of bone and dental tissues; an automated algorithm for evaluating spinal fusion quality through the objective Trabecular In-Growth Ratio (TIGR); a workflow for automated morphometric

analysis of large sets of biological samples applicable to evolutionary and genetic research; and a comprehensive multi-scale CT framework for additive manufacturing that integrates powder morphology, defect detection, and spatial resolution assessment.

The work demonstrates the candidate's strong analytical skills, deep understanding of CT physics, and ability to innovate across disciplinary boundaries. The integration of submicron and micro-CT datasets across diverse application domains not only reflects a high level of technical competence and creativity but also delivers outcomes directly applicable to scientific and experimental practice.

Importance for practice or development of the discipline:

The thesis significantly advances the application of X-ray computed tomography as a quantitative and reproducible tool for material characterisation. The developed methodologies and workflows are readily applicable in both scientific and applied research, providing reliable procedures for data calibration, segmentation, and quantitative analysis. In biological studies, the results enable precise morphometric and developmental analyses, while in materials science they support quantitative evaluation and quality control in additive manufacturing. By integrating computational processing with experimental CT data, the work strengthens the methodological foundation of modern materials research and its practical implementation.

Formal adjustment of the thesis and language level:

The thesis is written in clear and technically precise English. The work is well structured, and the use of figures and references appropriately supports the presentation of results. The writing reflects a mature academic style, and no significant linguistic or formal deficiencies were identified.

Questions and comments:

1. Do you see potential for integrating machine learning or artificial intelligence into the quantitative analysis procedures presented in the thesis?

2. The work introduces a multi-scale approach combining micro-CT and submicron-CT imaging. What are the main challenges in integrating data across these scales, and how did you overcome them?

Conclusion:

The dissertation 'Material evaluation and characterisation by X-ray computed tomography' presented by Ing. Jakub Lázňovský is a comprehensive, original, and methodologically mature work. It demonstrates the author's ability to conduct independent scientific research, develop innovative analytical methodologies, and contribute meaningfully to interdisciplinary scientific progress.

In my opinion, the reviewed thesis fulfils all requirements posed on theses aimed for obtaining PhD degree. This thesis is ready to be defended orally, in front of respective committee.

In Prague, date: 05.12.2025

doc. Ing. Ladislav Pína, DrSc.

CEITEC – Středoevropský technologický institut
Vysoké učení Technické v Brně
Purkyňova 656/123, 612 00 Brno
www.ceitec.eu