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To get the most out of high resolution X-ray tomography: a review of the post-reconstruction analysis

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Abstract

X-ray microscopy has been well-recognized as one of the most important techniques for research in a wide range of scientific disciplines including materials science, geoscience, and bio-medical science. Advances in X-ray sources, optics, detectors, and imaging methodologies have made significant improvements to non-destructive reconstructions of the three dimensional (3D) structure of specimens over a wide range of length scales with different contrast mechanisms. A strength of 3D imaging is a "seeing is believing" way of reporting and analyzing data to better understand the structure/function characteristics of a sample. In addition to the excellent visualization capability, X-ray computed tomography has a lot more to offer. In this article, we review some of the experimental and analytical methods that enrich and extract scientifically relevant information from tomographic data. Several scientific cases are discussed along with how they enhance the tomographic dataset.

Keywords: X-ray; tomography; three-dimensional imaging; post-processing.

1. Introduction

X-rays have been used for imaging ever since they were discovered by Wilhelm Conrad Röntgen in the year 1895 [1]. One of the most attractive characteristics of X-rays is their penetration capability, which allows non-invasive probing of the specimen's internal structure. In the 1970s, Allan M. Cormack and Godfrey Newbold Hounsfield brought X-ray radiography into a new era with the ground breaking development of the computed tomography (CT) technique [2]. Using this technique, a series of projection images are acquired as the sample is rotated around an axis perpendicular to the incident X-rays. The 3D structure of the sample is then reconstructed numerically, which allows the internal features to be investigated while avoiding the uncertainty in a projection radiograph caused by overlapping features along the beam path.

Over the past few decades, the evolving tomography technique has had great impact in a wide range of scientific research areas and clinical applications. With the technological developments in X-ray components and improvements in imaging algorithms, the X-ray tomography technique is now capable of covering a wide range of length scales using different hardware configurations and utilizing different contrast mechanisms.

1.1. X-ray microscopy configurations