# Popular Science Abstract

## "Beyond traditional tomography: X-ray multi-projection imaging for additive manufacturing"

María Esther Vilar Álvarez

June 2023

Chances are, you've already come across the fascinating world of X-ray tomography, particularly in the realm of medicine, where tomography scans have become a regular feature in hospitals. These groundbreaking techniques harness the power of X-rays to create detailed internal images, giving us a unique glimpse into the human body. But the uses of X-rays, extend far beyond medicine. Their extraordinary ability to penetrate matter, owing to their high frequency is pivotal in the study of both the macroscopic and microscopic aspects of our world, by providing us an insight into the hidden 3D structure of objects. That is why researchers are actively and continually developing innovative methods in order to improve and augment the analysis of various materials using X-rays.

But how exactly does X-ray tomography occur? The working principle is simple to understand. When an object is rotated within a specific angular range, an X-ray beam is directed through the object, X-ray projections from various angles are captured. These 2D projections are subsequently compiled and processed, finally allowing the original 3D structure of the sample to be faithfully restored and visualized. And this is where the interesting part comes into play. From a technical standpoint, the successful reconstruction of the final object relies on the utilization of numerous projections. Because mathematically speaking, the greater the number of projections employed, the richer the information conveyed about the 3D structure. Traditional reconstruction algorithms that use the projection data to reach the final step of retrieving the 3D morphology require a complete set of projections to effectuate the reconstruction. Otherwise, they fail. Can it then be possible, to fully reconstruct an object if the number of projections is drastically lowered?

This was the primary aim of the project work, accomplishing a 3D reconstruction with only a minimal number of projections. To achieve this, it is necessary to surpass the limitations of conventional X-ray tomography, calling for the adoption of a pioneering technique, referred to as X-ray multi-projection imaging (XMPI). Strikingly similar to X-ray tomography, XMPI differs in one crucial aspect: the X-ray projections at different angles are collected simultaneously. This key component highlights the superiority of XMPI; by collecting projections at multiple angles simultaneously, it is capable of capturing a greater amount of information about the 3D structure in a shorter period of time. Furthermore, it enables faster imaging processes and reduces the potential for motion artifacts!

To tackle this challenge, the XMPI technique incorporates a powerful deep learning algorithm called ONIX. By fusing the physical principles underlying the interaction of X-rays with matter and the algorithm's capacity to discern intricate patterns from the data, we can confidently assert that the answer to our previous question is a resounding "yes"! Using only a sparse number of projections, ONIX enables the successful 3D reconstruction of an object.

This remarkable achievement showcases the potential of combining advanced machine learning techniques with the fundamental physics of X-ray imaging. This holds immense significance for fields like additive manufacturing, also known by its other common name of 3D printing. The dynamic study of material behavior during the manufacturing process is a vital area under active development as the ability to capture fast dynamics is important for understanding the material's evolving characteristics. However, the conventional working principle of tomography poses a challenge in this context, as the sample rotation necessary for 3D data collection cannot keep pace with the rapid changes occurring in the material. By employing XMPI with its reduced number of projections, it will become feasible to achieve the desired fast dynamics imaging and still retain high-quality reconstructions!