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Comparison of convolutional neural network architectures for tomographic reconstruction from incomplete data.

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Neutron tomography is a powerful tool in material science due to the large penetration depth, sensitivity to light elements and good contrast for elements with close atomic numbers. Such properties of the interaction of neutrons with matter make it possible to obtain data on the internal structure of objects that complement X-ray tomography. However, a significant disadvantage of the method remains the long duration of the experiment. With some exceptions, it takes up to several hours on most installations to obtain the number of radiographic projections satisfying the Nyquist–Shannon theorem. In turn, this does not allow for the study of large series of samples, which is required to obtain statistically significant results in areas such as archaeology. Prolonged exposure to the neutron beam exposes the studied objects to a greater radiation load, which also imposes restrictions on the study of valuable or rare archaeological artifacts. Thus, there is a need for comprehensive development of the neutron tomography method.

One possible way to reduce the time of conducting neutron tomography experiments may be to use fewer radiographic projections. However, tomographic reconstruction from an incomplete data set using standard methods such as filtered back projection (FBP) or simultaneous algebraic reconstruction (SART) leads to low-quality three-dimensional models. Reconstruction methods based on convolutional neural network (CNN) make it possible to circumvent the limitations of classical algorithms. CNNs have proven themselves primarily as a tool for working with images, since they require fewer trainable parameters compared to a fully connected perceptron and reveal the spatial relationship between pixels well.

In this work, the effectiveness of convolutional neural networks in tomography reconstruction algorithms using incomplete data was investigated. Several CNN architectures were compared by test calculations on the Shepp-Logan phantom, as well as on real experimental data. The robustness of the developed algorithms was evaluated with minor fluctuations in the volume of input data. The use of convolutional neural networks made it possible to reduce by 80% the required number of projections for high-quality reconstruction.

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