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Exploring interpretable deep learning architectures for anomaly detection in SOLARIS synchrotron

The National Synchrotron Radiation Center SOLARIS, third generation light source, is the only synchrotron located in Central-Eastern Europe, in Poland. The SOLARIS Center, with seven fully operational beamlines, serves as a hub for research across a diverse range of disciplines. The most important aspect of such research infrastructure is to provide stable working conditions for the users, operators and the conducted projects. Due to its unique properties, problem complexities, and challenges that require advanced approaches, the problem of anomaly detection and automatic analysis of signals for the beam stability assessment is still a huge challenge that has not been fully developed. To address this problem, an automatic analysis of diagnostic signals on the example of transverse beam profiles has been proposed. Pinhole beamlines are typically installed in the middle and high-energy synchrotrons to thoroughly analyze emitted X-rays and therefore assess electron beam quality. To address the problem, pre-trained convolutional neural network (CNN) models in soft fine-tuning strategy were utilized. Created from scratch database contains over one million transverse beam profile images. The best proposed solution, based on the InceptionV3 architecture, can assess beam quality automatically, based solely on the image itself. It classifies pinhole beamline images into two classes (anomaly/non anomaly) with 94.1% accuracy and 96.6% precision. Finally, interpretability algorithms were employed to perform an analysis of the models and achieved results.

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