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spear_tools: Deep learning allrounder for free-electron-laser pulse characterization

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The ultrashort and ultraintense pulses produced by X-ray free-electron lasers (XFELs) realize exposure times that typically lie in the femto- or even attosecond range. One of the long-term goals at free-electron lasers is to develop a diagnostic tool able to characterize the elusive temporal profile of these pulses in real-time and thus open new fields of atto-science with X-rays. In a practical regard, such an opportunity would also accelerate the progress during experimental campaigns as well as the data analysis afterward. We propose spear_tools – a framework suitable to do so using deep learning algorithms for the angular-streaking methodology, which emerged as a non-destructive technique able to retrieve the time-energy structure of XFEL pulses on a single-shot basis with attosecond resolution.
Currently, the framework includes these functionalities:
• Several simulation data generators necessary for neural network training
• A neural network development platform, including progress visualization
• Evaluation pipelines suitable for real-time and post-beamtime usage
• Visualization dashboards that can be used during and after experimental campaigns
spear_tools is suitable for beginners and advanced programmers, as only configuration files need to be changed or Jupyter Notebooks launched to get started. With its modular structure, spear_tools offers the option of quickly integrating custom simulation environments as well as neural network architectures and, beyond that, the extension to use cases other than the one presented here. Currently, the framework is only working in the simulation environment, but continuous developmental steps are taken to bring the analysis also to experimental data.

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