Automatic scanning and benchmarking of thin film targets using Machine Learning techniques

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As the laser-based particle accelerators emerged at a global scale in the last decade, more and more research interest and effort is put in further developing and improving acceleration techniques and supporting technologies. The impressive results achieved and tools developed lately in the Machine Learning field can play an important role in driving further the refinement and optimization of both the machine operation and the data analysis in order to strengthen the use of high power lasers in fundamental, medical or material science research.

The requirement for advanced acceleration mechanisms resulting in particle beams with high energy cutoff, tunable spectrum and spatial homogeneity is pushing for specific targets i.e. ultra-thin films of few nanometers. In such cases it is required to analyze under the microscope the surface quality of the target and to identify the flattest area to be shot, that is not trivial due to the very low thickness. The bad areas of a target are much more visible due to the fact that the wrinkles and imperfections provides an optical structure for the light to unevenly scatter, while the flat ones are almost transparent, however indirectly visible owing to the presence of dust on the surface.

Our approach is to develop an automatic scanning setup and algorithm that is capable of computing a flatness map of each target by analyzing the images from a microscope. The algorithm is based on Machine Learning techniques and models (namely Convolutional Neural Networks) that are trained on datasets which are both manually labeled and augmented using artificial generative approaches (like Generative Adversarial Neural Networks).

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