Optimising the layout of tomographic diagnostics with Genetic Programming

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Radiation measurements are essential for the operation of next-generation tokamaks, as they provide key information on plasma conditions and support control strategies. Diagnostics such as bolometers, soft X-ray detectors, and scintillators are widely employed for this purpose. However, the design of an effective detection layout is strongly constrained by the limited access provided by tokamak ports, which directly impacts the accuracy of tomographic reconstructions. Additional constraints arise from the different accuracy requirements across regions of interest, such as the divertor and the X-point radiator. In this work, we present a methodology for optimizing acquisition geometries in tomographic diagnostics. The approach is based on maximum likelihood tomography, which enables both image reconstruction and uncertainty propagation. The optimization strategy aims to identify geometries that satisfy the accuracy requirements in any specific region, while minimizing overall uncertainty levels. The objective is to determine configurations that improve reconstruction fidelity and reduce sensitivity to measurement noise. The optimization is performed using a Genetic Algorithm, a machine learning approach inspired by evolutionary processes. This method is particularly well suited for problems with strong geometric constraints. Several algorithmic configurations are investigated, analysing the influence of key hyperparameters such as mutation rate and crossover rate on the resulting solutions. The final configuration is selected by balancing reconstruction accuracy and system complexity. The methodology is ultimately validated on a reactor-scale tokamak, demonstrating its capability to provide optimized solutions under different scenario constraints.