



# Matrix-Free Algorithms for Smoothing Large Data Sets

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Smoothing a data set refers to creating an approximating function that captures important patterns in given data while leaving out noise and other fine scaled structures. Several approaches, such as the penalized spline method, are known to work well if the number of covariates is relatively small. For an increasing number of covariates, however, these methods suffer from an exponential growth of computational complexity in the sense of run-time and memory requirements.

To address this issue, matrix-free optimization algorithms are proposed that allow for determining the P-spline function using a negligible amount of memory and are therefore applicable for an arbitrary number of covariates. Further, to improve the run-time of the algorithms, a numerically sophisticated preconditioning technique is introduced, leading to algorithmic scalability.

Using appropriate extensions, the model can be applied to a wide range of practical problems and the usefulness of the proposed algorithms is shown on selected practical examples as well as on numerical tests.