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Multiway data regression using a spline-type tensor decomposition

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An important research trend is the transition from vector and matrix based mathematical engineering to generalizations that make use of higher-order tensors. Tensor-algorithms have revolutionised high-dimensional computations. In machine learning or more specifically supervised learning, the potential still largely has to be unleashed [5]. In supervised learning, one searches for an approximation of a nonlinear map. This is done for example with neural networks or support vector machines. Polynomials and splines can also be used, thanks to tensor decompositions that allow for a compact representation of multivariate polynomials and splines [1].

Previously, a similar model was studied specifically with polynomials [4]. These are easy to represent and allow for a uniform approximation of continuous functions, but fall short when nonlinearities are present in the approximated map. In this research [6] splines are used. These give the same advantages, but also allow the approximation of isolated nonlinearities [3]. The extra difficulty is the placement of the spline-knots.

The contribution of this research is a general solution method to approximate an unknown map, based on noisy data [2]. Different implementations have been compared. For classical multivariate splines, one has an exponential time and memory complexity in function of the number of input-variables. With this model it is reduced to a linear complexity. Finally, a few heuristic methods for placing the spline-knots are compared.

References

[1] G. Beylkin, J. Garcke, M. J. Mohlenkamp, *Multivariate Regression and Machine Learning with Sums of Separable Functions*, SIAM, (2009) pp. 1840-1857.

[2] M. Boussé, N. Sidiropoulos, L. De Lathauwer, *NLS Algorithm for Kronecker-Structured Linear Systems with a CPD Constrained Solution*, EUSIPCO, (2019) pp. 1-5.

[3] N. Govindarajan, N. Vervliet, L. De Lathauwer, *Regression and classification with spline-based separable expansions*, Technical Report 21-67, ESAT-STADIUS, KU Leuven (Leuven, Belgium), 2021

[4] S. Hendrikx, M. Boussé, N. Vervliet, L. De Lathauwer, *Algebraic and optimization based algorithms for multivariate regression using symmetric tensor decomposition*,

[5] N. Sidiropoulos, L. De Lathauwer, X. Fu, K. Huang, E. Papalexakis, C. Faloutsos, *Tensor Decomposition for Signal Processing and Machine Learning*, IEEE, (2017) pp. 3551-3582.

[6] R. Widdershoven, L. De Lathauwer, N. Govindarajan, M. Boussé, N. Vervliet, *Spline-type tensorontbindingen voor gesuperviseerd leren*, Leuven : KU Leuven. Faculteit Ingenieurswetenschappen, Leuven, 2021.