TECHNISCHE UNIVERSITÄT CHEMNITZ

Fast Algorithms for Explainable Recommendation Systems

SAlE

AP1. Recommender Systems for Price Optimization

Dynamic Pricing, Real-Time Scoring

SP1. Learning With High-Dimensional Additive Models

Data Approximation, Interpretation, Explainability

AP2. Recommender Systems for E-Learning Modules

Predictive Analytics, Adaptivity

SP2. Fast Approximation for Large-Scale Learning

Machine Learning, Robustness

SP3. Large-Scale Optimization for Image Processing

Variational Models, Non-Linear Optimization

prudsys Member of the GK Software Group

Application Partner prudsys AG

More than 200 customers in 34 countries

e.g. babywalz, bonprix, C&A, Coop, Douglas, Klingel, Obi, Sanicare, Thalia, Würth

BPS GMBH www.bps-system.de

Application Partner BPS Bildungsportal Sachsen GmbH

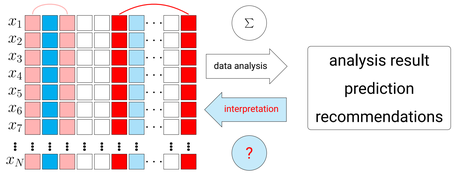
Over 70.000 students, 22 customers, 16 partners

e.g. Uni Leipzig, TU Dresden, DAA GmbH, BIBB, Georg Thieme Verlag KG, MAN Truck & Bus AG, edu-sharing e.V.

ger.: **S**chnelle **AI**gorithmen für transparente **E**mpfehlungssysteme

Idea and goals of the project

- As the storage of data increases, so do the requirements placed on processes for their meaningful and, above all, transparent analysis.
- Goal of this project: Develop efficient algorithms for data analysis, which allow **conclusions to be drawn about the decision-making process** (explainable AI).



- The focus is particularly on methods related to the **analysis of variance** (ANOVA).
- Based on the **ANOVA decomposition** of a function

$$f(\boldsymbol{x}) = f_\emptyset + \sum_{i=1}^{d} f_{\{i\}}(\boldsymbol{x}) + \sum_{i,j=1,i<j}^{d} f_{\{i,j\}}(\boldsymbol{x}) + \cdots + f_{\{1,2,\ldots,d\}}(\boldsymbol{x})$$

  interactions between dimensions can be analyzed.
- We assume a **sparsity**, which is given in many practical applications (sparsity of effects).
- **Sensitivity analysis:** The global sensitivity indices (gsi) indicate which dimensional couplings are important in the data.

Example (function in 9D):

$$f(x_1,\ldots,x_9) = u(x_1,x_3,x_8) + v(x_2,x_5,x_6) + w(x_4,x_7,x_9)$$

with active set $\mathcal{A} = \mathcal{P}(\{1,3,8\}) \cup \mathcal{P}(\{2,5,6\}) \cup \mathcal{P}(\{4,7,9\})$

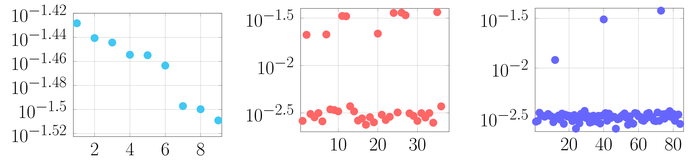
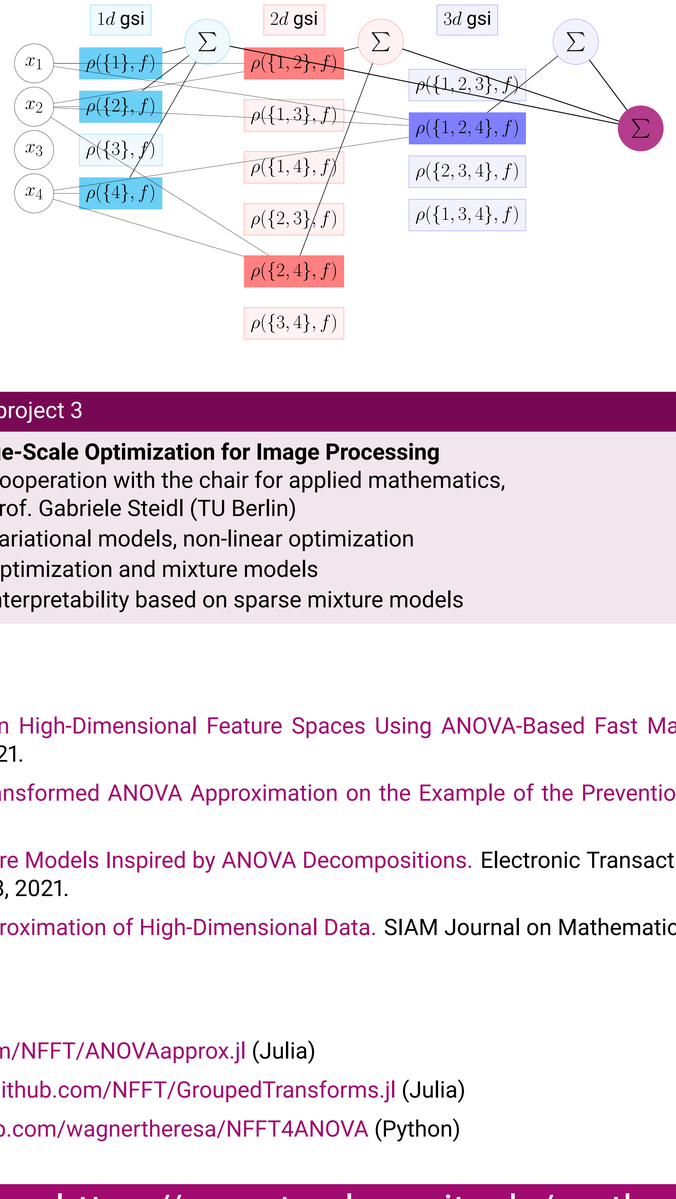


Figure: Approximation problem in 9D, influence (gsi) of single dimensions and their interactions.

An explainable ANOVA network:



Subproject 1

Learning With High-Dimensional Additive Models

- Cooperation with the chair for applied functional analysis, Prof. Daniel Potts (TU Chemnitz)
- Fast Algorithms for high-dimensional approximation
- FFT-based methods
- Interpretability based on the ANOVA decomposition in Fourier domain

Subproject 2

Fast Approximation for Large-Scale Learning

- Cooperation with the chair for scientific computing, Prof. Martin Stoll (TU Chemnitz)
- Machine learning, fast methods for matrix-vector multiplication
- Kernel based methods (ridge regression, SVM, spectral clustering)
- Interpretability via ANOVA kernels

Subproject 3

Large-Scale Optimization for Image Processing

- Cooperation with the chair for applied mathematics, Prof. Gabriele Steidl (TU Berlin)
- Variational models, non-linear optimization
- Optimization and mixture models
- Interpretability based on sparse mixture models

People

Dr. F. Nestler
Head of project

Prof. D. Potts
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Publications

F. Nestler, M. Stoll, T. Wagner: Learning in High-Dimensional Feature Spaces Using ANOVA-Based Fast Matrix-Vector Multiplication. arXiv: 2111.10140, 2021.

D. Potts, M. Schmischke: Interpretable Transformed ANOVA Approximation on the Example of the Prevention of Forest Fires. arXiv: 2110.07353, 2021.

J. Hertrich, F. A. Ba, G. Steidl: Sparse Mixture Models Inspired by ANOVA Decompositions. Electronic Transactions on Numerical Analysis, vol. 55, pp. 142–168, 2021.

D. Potts, M. Schmischke: Interpretable Approximation of High-Dimensional Data. SIAM Journal on Mathematics of Data Science, 3 (4), 1301–1323, 2021.

Software

D. Potts, M. Schmischke: https://github.com/NFFT/ANOVAapprox.jl (Julia)

F. Bartel, D. Potts, M. Schmischke: https://github.com/NFFT/GroupedTransforms.jl (Julia)

F. Nestler, M. Stoll, T. Wagner: https://github.com/wagnertheresa/NFFT4ANOVA (Python)