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Explicit functional ANOVA and new results in model and algorithm explainability and sensitivity analysis

We present a unified perspective on explicit functional ANOVA as a principled decomposition framework for black-box models, bridging explainability, sensitivity analysis, and algorithmic understanding. We derive an exact closed-form functional ANOVA for categorical inputs, valid under arbitrary dependence structures and even on sparse or non-rectangular supports, thereby removing a major limitation of standard ANOVA-based methods outside the independent setting. It extends other new results showing that classical Fourier analysis on the Boolean hypercube is in fact a particular case of Hoeffding functional decomposition under the uniform product measure. These results yield tractable decompositions that preserve hierarchical orthogonality, recover the classical orthogonal ANOVA in regular regimes, and naturally induce generalized SHAP-like feature attributions in machine learning. Beyond local and global explainability, they provide new tools to analyze interaction structure, detect spurious effects induced by encoding or dependence, compare models through their decomposed mechanisms, and study stability, robustness, and mismatch between algorithms and data distributions. They also suggest broader avenues for sensitivity analysis under dependence and for model compression through low-order effect dictionaries. Finally, these advances point toward continuous-input settings, notably because modern tabular architectures increasingly process numerical variables through learned embeddings or tokenizations, making explicit ANOVA on intermediate representations a promising route toward continuous-domain extensions.

Special/ Invited session

Uncertainty quantification and sensitivity analysis

Classification

Both methodology and application

Keywords

Functional ANOVA, Hoeffding, SHAP

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