
Generalized Functional ANOVA in Closed-Form: A Unified View of Additive Explanations

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Abstract

The functional ANOVA, or Hoeffding decomposition, provides a principled framework for interpretability by decomposing a model prediction into main effects and higher-order interactions. For independent inputs, this classical decomposition is explicit. It is closely connected to SHAP values, generalized additive models, and orthogonal polynomial expansions, and therefore constitutes a fundamental tool for additive explainability. In the more general and realistic dependent setting, however, obtaining a tractable representation and estimating the decomposition from data remain challenging. In this work, we address this problem for continuous inputs. By combining Hilbert space methods with the generalized functional ANOVA, we build an explicit decomposition basis allowing to easily compute the decomposition. Our formulation recovers the classical independent case and its associated orthogonal decomposition. Building on this representation, we propose a simple but mighty algorithm to estimate the decomposition from a data sample in a model-agnostic setting and we compare it empirically with several state-of-the-art explanation methods, demonstrating the power of the approach.

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