Sparse modeling of factorial experiments with Bayesian finite mixtures

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ABSTRACT

In experimental design, a common structure in data one often encounters involves multiple inputs purposely altered to different levels to efficiently study its relation to the resulting outputs. A factorial experiment refers to a specific setting where each input is constrained to have finitely many levels (either qualitative or quantitative) resulting in experimental units defined over finitely many combinations of these input levels. An experiment with this structure is not only common in natural sciences, but also known as conjoint analysis in marketing, and computational techniques in Machine Learning such as grid search can also be considered a variant of this practice. Our work aims at recovering a sparse probabilistic representation of experimental units from factorial experiment data by grouping together levels within each input so as to drastically reduce the dimension of the experimental design. While a work of similar nature in Bayesian paradigm was previously attempted by Nobile and Green (2000)[1], their model failed to achieve one-to-one correspondence to data because of limited handing of identification of mixture models under the complicated dependence structure introduced through the factorial design. Our work based on methods developed by Frühwirth-Schnatter, Malsiner-Walli and Grün (2020)[2] as well as on recent development in experimental design aims at resolving these identification problems. This ultimately allows for more concise inference on otherwise combinatorially increasing design space and also gives informative statistics to run follow-up experiments targeted at reducing the uncertainty in a specific group of experimental units.

References

[1] Agostino Nobile and Peter J Green. Bayesian analysis of factorial experiments by mixture modelling. *Biometrika*, 87(1):15–35, 2000.

[2] Sylvia Frühwirth-Schnatter, Gertraud Malsiner-Walli, and Bettina Grün. Dynamic mixtures of finite mixtures and telescoping sampling. *arXiv preprint arXiv:2005.09918*, 2020.