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Causal inference in Geosciences with multidimensional kernel deviance measures

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Causal inference methods, compared to other data-driven empirical learning methods, such as probabilistic modeling, kernel machines, or deep learning, which mainly focus on prediction and classification, aim at discovering and explaining the causal structure of the underlying system. Essentially, observational causal discovery aims at extracting potential causal relationships from multivariate datasets, which goes beyond the commonly adopted correlation approach. Recently Mitrovic et al 2018 [1], proposed a measure, Kernel Conditional Deviance for Causal Inference (KCDC), for determining the causal direction between two variables, with promising results on simulated and observed datasets where the groundtruth has been reasonably established. The assumption behind the method is algorithmic independence between the conditional probability p(effect|cause) and the level of the cause. By comparing the structural variability between the conditional distributions in both directions, an asymmetry is established and the true causal direction determined. In this paper, we apply the measure to remote sensing and geoscience datasets to which this method has not yet been applied. We use both observational data where expert domain knowledge is available and used to establish the causal direction, as well as simulated data from radiative transfer models such as PROSAIL [2]. We also explore the suitability of KCDC beyond the two variable case to the multivariable case and use it to infer the underlying DAG causal mechanisms. We win ll present results comparing with similar methods and analyzing the sensitivity to hyperparameter choices.

[1] Mitrovic et al., Causal Inference via Kernel Deviance Measures, NIPS 2018
[2] Perez-Suay and Camps-Valls, 2018. Causal Inference in Geoscience and Remote Sensing from Observational Data, IEEE TGARS 2018