Invariant Causal Prediction: Identification and Confidence Intervals, Sequential Data

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مقدمه:

در این ارائه، یکی از مباحث مهم در زمینه استنتاج علّی بررسی می‌شود؛ ناوردایی در مشاهده متغیرهای مدل علّی یا غیرعلّی. در این موضوع، یک مقاله کامل، نوشته شده توسط پیترز، بولمن و ماینشازن (افراد شناخته شدن در حوزه استنتاج علّی) نوشته شده است ([۱])، در انتهای این مقاله نیز گفتگوی جالبی میان خوانندگان بوجود آمده و حتی یک ایراد نیز به این مقاله وارد آمده که توسط نویسندگان آن پاسخ داده شده است که در ارائه به این گفتگو اشاره خواهیم کرد. مقدمه (abstract) این مقاله این چنین است:

What is the difference between a prediction that is made with a causal model and that with a non-causal model? Suppose that we intervene on the predictor variables or change the whole environment. The predictions from a causal model will in general work as well under interventions as for observational data. In contrast, predictions from a non-causal model can potentially be very wrong if we actively intervene on variables. Here, we propose to exploit this invariance of a prediction under a causal model for causal inference: given different experimental settings (e.g. various interventions) we collect all models that do show invariance in their predictive accuracy across settings and interventions. The causal model will be a member of this set of models with high probability. This approach yields valid confidence intervals for the causal relationships in quite general scenarios. We examine the example of structural equation models in more detail and provide sufficient assumptions under which the set of causal predictors becomes identifiable. We further investigate robustness properties of our approach under model misspecification and discuss possible extensions. The empirical properties are studied for various data sets, including large-scale gene perturbation experiments.

در ادامه نیز مقاله‌ی جدیدی ([۲])، ارائه شده در سال ۲۰۱۸ با موضوع ناوردایی علّی در سری‌های زمانی، نوشته شده توسط فیستر، بولمن و پیترز بررسی می‌شود و کاربرد این موضوع در سری‌های زمانی نیز مشخص می‌گردد؛ که برای مثال نشان دهده می‌شود در محیط‌های حاکم با سری‌های زمانی خطی، حتی بدون آنکه محیط شناخته شده باشد، می‌توان روابطی علّی خاصی را استخراج کرد. مقدمه (abstract) این مقاله نیز این چنین است:

We investigate the problem of inferring the causal predictors of a response Y from a set of d-explanatory variables (X^1, …, X^d). Classical ordinary least squares regression includes all predictors that reduce the variable Y. Using only the causal predictors instead leads to models that have the advantage of remaining invariant under interventions; loosely speaking they lead to invariance across different “environments” or “heterogeneity patterns”. More precisely, the conditional distribution of Y given its causal predictors remains invariant for all observations. Recent work exploits such a stability to infer causal relations from data with different but known environments. We show that even without having knowledge of the environments or heterogeneity pattern, inferring causal relations is possible for time-ordered (or any other type of

sequentially ordered) data. In particular, this allows detecting instantaneous causal relations in multivariate linear time series which is usually not the case for Granger causality. Besides novel methodology, we provide statistical confidence bounds and asymptotic detection results for inferring causal predictors, and present an application to monetary policy in macroeconomics.

منابع:

[1] Causal Inference by Using Invariant Prediction: Identification and Confidence Intervals; 2018; Jonas Peters, Peter Bühlmann and Nicolai Meinshausen

[2] Invariant Causal Predicion for Sequential Data; 2018; Niklas Pfister, Peter Bühlmann and Jonas Peters