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New symbolic regression methods for estimating parameter transfer functions for hydrological models

Moritz Feigl, Daniel Klotz, Mathew Herrnegger, and Karsten Schulz
Institute of Hydrology and Water Management, University of Natural Resources and Life Sciences, Vienna, Austria

Parameter estimation for spatially distributed rainfall-runoff models is a long studied and difficult problem. Linkages between catchment properties (such as elevation, slope or soil texture) and model parameters have the potential to cope with some of the major difficulties associated with parameter estimation. One way to establish these linkages is to use explicit equations that act as “parameter transfer functions”, which map spatially distributed catchment properties to the model parameters. These transfer functions would allow the estimation of consistent spatially distributed model parameter fields and potentially allow to extrapolate parameter to other basins (i.e. regionalization, see: Samaniego et al., 2010; Samaniego et al., 2017). However, the form and structure of transfer functions is often only implicitly assumed or needs to be derived by a laborious literature guided trial and error process (see: Samaniego et al., 2017) .
Recent results by Klotz et al. (2017) suggest that it is possible to simultaneously estimate the structure and the parameters of transfer functions from catchment runoff data by using symbolic regression approaches. However, the proposed method therein was still relatively unstable, in the sense that solutions very close to an optimum are represented by different inferred transfer functions (especially for more complex models). This instability results in an uncertainty about the uniqueness of the resulting optimal function.
This contribution therefore analyses the trade-off between computational costs, goodness of fit and generative expressiveness (i.e. which and how many transfer function can be generated by a given method) of different symbolic regression methods. To accomplish this, the study compares different symbolic regression approaches on the basis of a synthetic problem that can be analyzed with ease. The novel methods are based on techniques for projecting the transfer function estimation problem into different (search) spaces. The results suggest that methods which uses two separate optimization mechanism (e.g. one for the structural search and one for the transfer function coefficients) are computationally too expensive for practical purposes. This also holds true for methods where a reasonable subset of possible transfer functions have to be calculated beforehand. Subsequently, it is proposed to use methods,which directly estimate the entire equation of the transfer functions (structure and parametrization) in a single step.

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