Mach Learn (2012) 89:183–211
DOI 10.1007/s10994-012-5318-3

Learning monotone nonlinear models using the Choquet integral

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Received: 7 November 2011 / Revised: 17 July 2012 / Accepted: 19 July 2012 /
Published online: 10 August 2012

Abstract The learning of predictive models that guarantee monotonicity in the input variables has received increasing attention in machine learning in recent years. By trend, the difficulty of ensuring monotonicity increases with the flexibility or, say, nonlinearity of a model. In this paper, we advocate the so-called Choquet integral as a tool for learning monotone nonlinear models. While being widely used as a flexible aggregation operator in different fields, such as multiple criteria decision making, the Choquet integral is much less known in machine learning so far. Apart from combining monotonicity and flexibility in a mathematically sound and elegant manner, the Choquet integral has additional features making it attractive from a machine learning point of view. Notably, it offers measures for quantifying the importance of individual predictor variables and the interaction between groups of variables. Analyzing the Choquet integral from a classification perspective, we provide upper and lower bounds on its VC-dimension. Moreover, as a methodological contribution, we propose a generalization of logistic regression. The basic idea of our approach, referred to as choquistic regression, is to replace the linear function of predictor variables, which is commonly used in logistic regression to model the log odds of the positive class, by the Choquet integral. First experimental results are quite promising and suggest that the combination of monotonicity and flexibility offered by the Choquet integral facilitates strong performance in practical applications.

Editors: Dimitrios Gunopulos, Donato Malerba, and Michalis Vazirgiannis.

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