Hyperrectangles Selection for Monotonic Classification by Using Evolutionary Algorithms

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Abstract. This is a summary of our article published in International Journal of Computation Intelligence Systems [1] to be part of the MultiConference CAEPIA'16 KeyWorks.

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1 Summary

The classification with monotonicity constraints, also known as monotonic classification, is an ordinal classification problem where a monotonic restriction is present: a higher value of an attribute in an example, fixing other values, should not decrease its class assignment [3]. The monotonicity of relations between the dependent and explanatory variables is very usual as a prior knowledge form in data classification [4]. To illustrate, while considering a credit card application, a \$1000 to \$2000 income may be considered a medium value of income in a data set. If a customer A has a medium income, a customer B has a low income (i.e. less than \$1000) and the rest of input attributes remain the same, there is a relationship of partial order between A and B: $B < A$.

Many data learning algorithms have been adapted to be able to handle monotonicity constraints in several styles. In this paper, we propose the utilization of Evolutionary Algorithms (EAs) for hyperrectangles' selection in monotonic classification tasks. Hyperrectangles are generalization of examples in $\mathbb{R}^n$, according to Nested Generalized Examples (NGE) theory for instance-based learning. Single and generalized examples coexist and hyperrectangles may be nested and inner hyperrectangles serve as exceptions to surrounding hyperrectangles. They constitute axis-parallel rectangle representations as in many of the rule learning systems.

Our goal is to increase the performance in this type of problem by means of selecting the best suitable set of hyperrectangles which optimizes the nearest hyperrectangle classification with monotonicty constraints. For this, we propose the Evolutionary Hyperrectangle Selection for Monotonic clasification by CHC

(*EHSMC-CHC*). First of all, we approximate the NGE theory to monotonic classification by formally providing some necessary definitions. Then, we use a quick process for generating the initial set of hyperrectangles based on a greedy approach. After this, we introduce the CHC model used as an EA to perform hyperrectangle selection. The chromosomes use a binary coding scheme to represent the selection or not of each hyperrectangle in the final set. We define a fitness function based on the accuracy (classification rate) and the Non-Monotonic Index (NMI) estimated in the training data.

The validity of the proposed method is studied in an exhaustive experimental study, comparing several representative monotonic learning algorithms belonging to both instance-based and rule learning paradigms [2]. They are OLM, MID, OSDL and monotonic k-NN. The experimental framework consists of 30 ordinal data sets and we use five performance metrics [2]: Acc, MAE, MAcc, MMAE, NMI and the number or rules generated. Their performance over the data sets employed with our proposal and the other existing monotonic learnes will be compared using the appropriate statistical tests.

The results showed that *EHSMC-CHC* will allow us to produce very accurate models with a low number of hyperrectangles with very few monotonicity ruptures. The comparison with the most important monotonic learning approaches, including both rule and instance based learners draws that *EHSMC-CHC* and MID are the best approaches compared with the other techniques. Moreover, our algorithm significantly outperforms OLM, OSDL and Mk-NN in Acc, MAE, MAcc and MMAE. Considering NMI and NRules, our approach is the best according to the statistical report.

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