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Selected Methods for Constructing Classifiers for Temporal Data

Abstract

This dissertation addresses the problem of constructing classifiers for temporal data represented in the form of temporal decision tables. Such data are commonly encountered in many application domains, including medicine, industry, sports, and monitoring systems for dynamic processes. In classical approaches to temporal concept approximation, temporal data are typically transformed into static feature representations describing entire time windows. Although this enables the use of conventional classification methods, it also leads to a simplification of the information contained in temporal dynamics. An alternative is provided by deep learning methods, which can process temporal data directly but at the cost of reduced model interpretability.

The main objective of the dissertation was to develop interpretable classification methods for temporal data that directly exploit information contained within time windows without the need for prior aggregation. To achieve this goal, an original method called TC-Tree (Decision Tree with Temporal Cuts) was proposed. The method is based on the concept of temporal cuts, which enable the identification of relationships occurring within time windows and their use in the construction of decision-tree-based classification models. Furthermore, an extension of this approach, called VTC-Tree (Decision Tree with Verifying Temporal Cuts), was developed. The proposed method introduces a mechanism of verifying temporal cuts that provides additional support for classification decisions.

In addition, the dissertation presents a method for identifying and predicting changes in behavioral patterns using medical data related to respiratory failure in premature infants. This method constitutes a separate research component focused on the analysis of temporal changes in real-world data.

The proposed methods were evaluated experimentally using datasets originating from various application domains, including robot activity data, sports-related data, and medical data. The obtained results demonstrated that TC-Tree and VTC-Tree achieve classification performance comparable to, and in selected cases superior to, classical classification methods and selected deep learning approaches, including one-dimensional convolutional neural networks (1D-CNN) and Long Short-Term Memory networks (LSTM). At the same time, the proposed methods maintain a high level of interpretability, enabling the analysis of the decision-making process and the identification of rules responsible for object classification.

The conducted research confirmed that it is possible to construct interpretable classifiers for temporal data that operate directly on temporal observations without prior aggregation while maintaining classification performance comparable to selected classical machine learning methods and deep learning approaches.

Keywords: temporal data, data classification, temporal concepts, temporal cuts, decision trees, TC-Tree, VTC-Tree, data mining, interpretable machine learning.