Title	Perceptual and Position-aware Shapelet Networks for Time series Classification
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Citation	
Issue Date	2023-06
Type	Thesis or Dissertation
Text version	author
URL	http://hdl.handle.net/10119/18457
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Abstract

Shapelets are time series segments that effectively distinguish labels of time series. Recently, shapelet-based time series classifiers have garnered attention from the academic community, primarily due to their ability to produce accurate results while also being interpretable. However, these methods still confront challenges in both the shapelet initialization and shapelet learning phases, which can hinder their performance. In this dissertation, we propose two novel methods to effectively address these problems.

In our first work, we propose the Perceptual Position-aware Shapelet Network (PPSN), a novel shapelet-based classifier, to discover and optimize shapelets efficiently. PPSN leverages perceptually important points for extracting a limited number of high-quality shapelet candidates. These candidates are then evaluated using position-aware subsequence distance. In addition, we introduce Fixed Normalization (FN) and Stop-gradient Epochs (SGE) as two novel techniques for learning shapelets. Specifically, FN addresses the detrimental effects of different value ranges of shapelets' transformed values, while SGE mitigates the negative effects of non-optimal weights in the final linear layer. Results from experiments on 112 UCR datasets illustrate that our PPSN surpasses previous non-ensemble methods, and is competitive with HIVE-COTE 2.0, the current most accurate classifier while maintaining the benefits of interpretability and efficient computation time.

In our second work, we point out two other issues faced by existing shapelet-based methods. Firstly, they employ the soft-minimum function which only retrieves the minimum distance between a shapelet and its best-matching subsequences in the time series, neglecting other distances. Additionally, this function is prone to generating overflow values, which can result in the model not functioning properly in various scenarios. Secondly, previous methods use a General Classification Head to train shapelets, which is not optimized to capture the specific patterns in time series data. To address these problems, we propose PPSN++, a stronger shapelet-based time series classifier that extends our previous work PPSN. PPSN++ uses a Distance Learning Layer instead of the soft-minimum function, we also introduce a Binary Auxiliary Head which supports General Classification Head in training the shapelet for each specific class. Results from experiments on 112 UCR datasets show that PPSN++ outperforms PPSN, making it become the state-of-the-art shapelet-based method for this task.

Keywords: time series · classification · shapelet discovery · efficiency.