

Deep learning in time series analysis: Unlocking potential?

Annika Betken and Sophie Langer

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Detecting changes in time series - time points at which the statistical properties of a time series change significantly - is crucial in fields like climatology or neuroscience, where change-points may indicate changes in climate patterns or brain activity. Established change-point detection methods are typically designed for a specific change-point problem such as change in mean, variance or distribution. While these methods are computationally efficient and interpretable, they can be rather inflexible in cases where data information is lacking, e.g, where the type of change-point is unknown.

With the success of deep learning methods in applications such as image recognition and natural language processing, interest has grown in applying these techniques to change-point detection. [1] reformulated the change-point detection problem within a supervised learning framework using neural networks, allowing the method to automatically learn the appropriate test statistic and fine-tune its parameters for different types of changes and data distributions. While promising, [1] focus on specific data-generating processes and it remains questionable, if and when the deep learning-based approach really excels.

This master project aims to explore the advantages and limitations of deep learning-based change-point detection. We will compare these methods to traditional techniques, such as CUSUM, in various scenarios, including cases where conventional methods are optimal or where test statistics cannot be represented by neural networks. Additionally, we will investigate the impact of network depth on performance and the effect of data distribution changes. The project concludes with an extensive simulation study comparing the analysed approaches. As an outcome this project will provide a comprehensive comparison of traditional and deep learning-based methods for change-point detection and will potentially introduce hybrid versions leveraging strengths of both approaches.

References

- [1] Jie Li, Paul Fearnhead, Piotr Frylewicz, and Tengyao Wang. Automatic change-point detection in time series via deep learning. *To appear as discussion article in the Journal of the Royal Statistical Society Series B*, 2024.