PhD position:
Deep Learning for Time Series Classification

1 Dates and location

Starting date: Fall 2023

Duration: 3 years

Location: Mulhouse, France

2 Research Project

2.1 Context and motivation

Similarly to various fields like imagery, the last few years have seen the explosion in the amount of temporal data. These time series correspond to ordered sequences of numerical values or discrete events that evolve over time. Data ordering is a crucial element that makes it possible to characterize time series in order to study the similarity between a set of sequences. This then allows, for example, to recognize time series (classification), to group them together by similarity (clustering) or to detect anomalies in the series. In order to analyze time series, a technique mainly used considers small temporal windows to detect patterns representative of the temporal evolution. For several years now, the community of researchers in the field has been interested in approaches based on deep learning through the development of neural networks dedicated to time series [1]. For instance, the InceptionTime architecture [2], using the Inception module illustrated in Figure 1, is currently one of the most effective deep learning-base approach for time series classification.

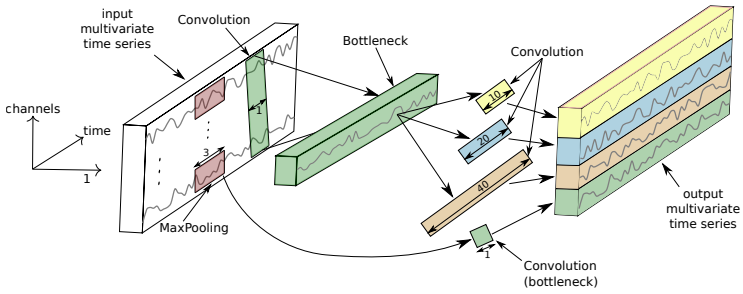

Figure 1: The Inception module proposed in the InceptionTime architecture for time series classification

2.2 Objectives

The objective of this thesis will thus be to study and develop new advanced deep learning methods for the analysis of time series and in particular for their classification. Initially, new deep architectures such as Transformers or diffusion models will be considered. Once a deep neural network is trained on a task from a dataset, its deployment and adaptation on different data (and potentially new tasks) is not easy. In a second step, we will therefore focus on transfer learning [3] and knowledge distillation [4] approaches in the context of time series analysis. Finally, one of the major challenges in deep learning concerns the interpretability and explainability of the decisions made by a neural network. In this thesis, we will finally study this problem and propose solutions to better understand the decisions made by deep models. This is particularly useful in a medical context, in the case of sequences of surgical acts analysis [5] or rehabilitation movement analysis. Thus, the theoretical approaches developed during the thesis will also be evaluated in the context of application cases mentioned above.

2.3 Research Environment

This research topic is the heart of the work of the MSD team from IRIMAS Institute at Université de Haute-Alsace. The candidate will benefit from a suitable research environment, rich in experience and skills on time series analysis. This PhD will be supervised by Prof. Germain Forestier, Dr. Jonathan Weber and Dr. Maxime Devanne.

3 Profile and application

3.1 Required profile

- Master in Computer Science (or equivalent)
- Good skills in Python programming
- Experience in Machine/Deep Learning

3.2 How to apply?

For applying to this PhD opportunity, please contact germain.forestier@uha.fr, jonathan.weber@uha.fr and maxime.devanne@uha.fr and provide us:

- A Curriculum,
- A cover letter
- Master transcripts

Application deadline: April 30th, 2023

References

[1] H. Ismail Fawaz, G. Forestier, J. Weber, L. Idoumghar, and P.-A. Muller, "Deep learning for time series classification: a review," *Data Mining and Knowledge Discovery*, vol. 33, no. 4, pp. 917–963, 2019.

[2] H. Ismail Fawaz, B. Lucas, G. Forestier, C. Pelletier, D. Schmidt, J. Weber, G. Webb, L. Idoumghar, P.-A. Muller, and F. Petitjean, "InceptionTime: Finding Alexnet for time series classification," *Data Mining and Knowledge Discovery*, vol. 34, no. 6, pp. 1936–1962, 2020.

[3] H. Ismail Fawaz, G. Forestier, J. Weber, L. Idoumghar, and P.-A. Muller, "Transfer learning for time series classification," in *IEEE International Conference on Big Data (Big Data)*, (Seattle, Washington), pp. 1367–1376, 2018.

[4] E. Ay, M. Devanne, J. Weber, and G. Forestier, "A study of knowledge distillation in fully convolutional network for time series classification," in *International Joint Conference on Neural Networks (IJCNN)*, pp. 1–8, IEEE, 2022.

[5] H. Ismail Fawaz, G. Forestier, J. Weber, L. Idoumghar, and P.-A. Muller, "Accurate and interpretable evaluation of surgical skills from kinematic data using fully convolutional neural networks," *International Journal of Computer Assisted Radiology and Surgery*, vol. 14, no. 9, pp. 1611–1617, 2019.