Data Augmentation for Time Series Classification with Deep Learning models

Gautier Pialla[1], Maxime Devanne[1], Jonathan Weber[1],
Lhassane Idoumghar[1], Germain Forestier[1]
[1] *IRIMAS, Université de Haute-Alsace, France*

gautier.pialla@uha.fr

Abstract

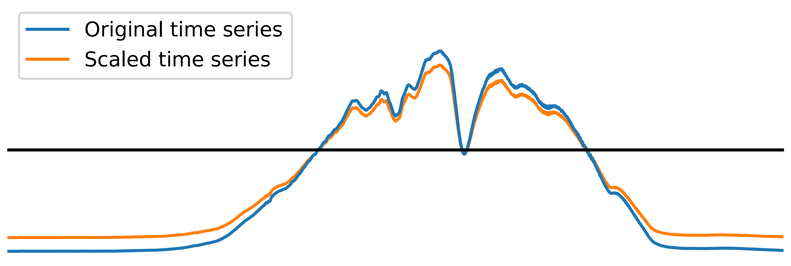
Data augmentation is systematically used for many learning tasks such as image classification. Regarding Time Series Classification (TSC), few works have been published. One of the most complete work is [1], but did not used InceptionTime in their benchmark. As InceptionTime is still regarded as one of the state-of-the-art deep learning models for TSC, we proposed to study data augmentation (DA) for both Inception and InceptionTime models.

Data Augmentation Methods

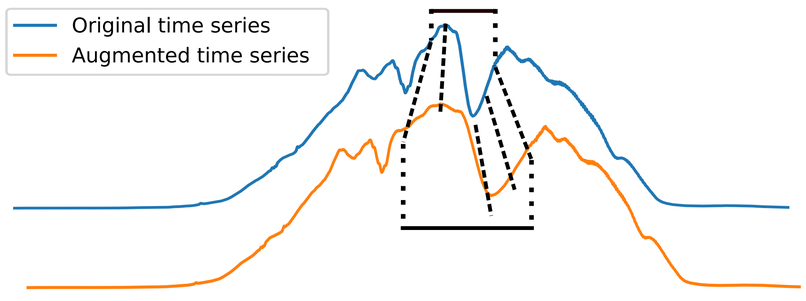
Random Guided Warping [2]:
Patterns are randomly switched over time series of the same class. The warping between time series is computed using DTW.

DGW [2]:
Here, only the most discriminative patterns are selected inside a batch.

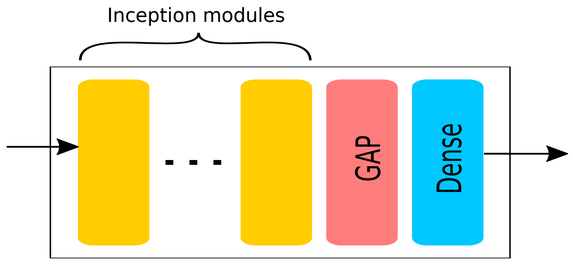
Scaling [3]:



Window Warping [4]:



Inception and InceptionTime



The Inception model is built with 6 Inception modules, followed by a Global Average Pooling layer and a Dense layer. InceptionTime is a ensemble of 5 Inception models. Currently, InceptionTime is one of the state-of-the-art deep learning models for TSC.

Experiments and results

Experiments with a single DA method:

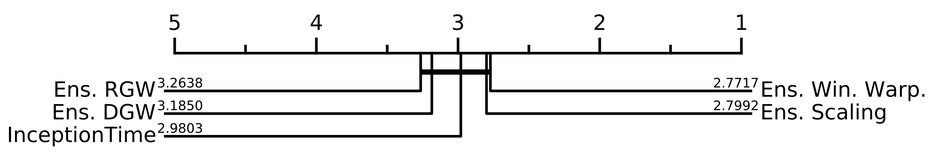


Figure 1: InceptionTime models trained with Scaling or Window Warping provide better results, although not significantly different.

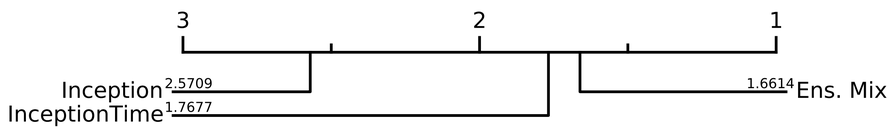


Figure 2: Ensemble of Inception models. Each Inception model is trained each with a different data augmentation method. This ensemble significantly outperforms InceptionTime.

Experiments with several DA method:

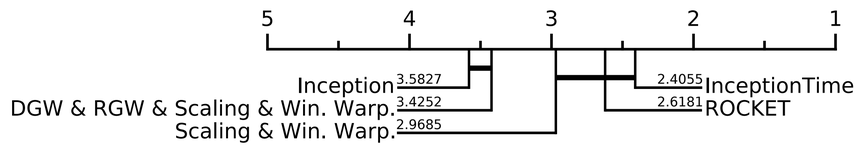


Figure 3: When using Scaling&Window Warping, a single Inception model obtains similar results as InceptionTime.

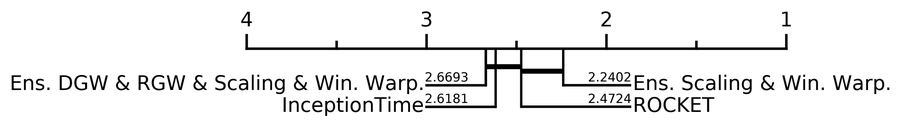


Figure 4: The ensemble trained with Scaling&Window Warping significantly outperforms InceptionTime.

Conclusion

- As for image classification, data augmentation helps deep TSC models to achieve better performances.
- Using several selected data augmentation methods significantly outperforms the models without augmentation.
- For ensembles, having each sub-model trained with a different data augmentation method significantly improves the accuracy.

References

[1] Iwana, B.K., Uchida, S.: An empirical survey of data augmentation for time series classification with neural networks. Plos one 16(7), e0254841 (2021)
[2] Iwana, B.K., Uchida, S.: Time series data augmentation for neural networks by time warping with a discriminative teacher. In: 2020 25th International Conference on Pattern Recognition (ICPR). pp. 3558–3565. IEEE (2021)
[3] Um, T.T., Pfister, F.M., Pichler, D., Endo, S., Lang, M., Hirche, S., Fietzek, U., Kuli cc, D.: Data augmentation of wearable sensor data for parkinson's disease mon- itoring using convolutional neural networks. In: Proceedings of the 19th ACM in- ternational conference on multimodal interaction. pp. 216–220 (2017)
[4] Le Guennec, A., Malinowski, S., Tavenard, R.: Data augmentation for time series classification using convolutional neural networks. In: ECML/PKDD workshop on advanced analytics and learning on temporal data (2016)

Acknowledgment

This work was funded by ArtIC project "Artificial Intelligence for Care" (grant ANR-20-THIA-0006-01) and co-funded by Région Grand Est, Inria Nancy - Grand Est, IHU of Strasbourg, University of Strasbourg and University of Haute-Alsace. The authors would like to thank the providers of the UCR archive as well as the Mésocentre of Strasbourg for providing access to the GPU cluster.