Master 2 internship at CNRS in LRCS Lab (Amiens, France)

Times Series Analysis in the Field of Battery using Deep Learning Models based on Attention

Laboratory: LRCS (CNRS)
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Required skills: Time series analysis, Machine/Deep Learning, Data Science, Python coding
Contract dates: from February to July 2024
Salary: 550€/month (net)
Keywords: Time series, Deep learning, Energy, Battery

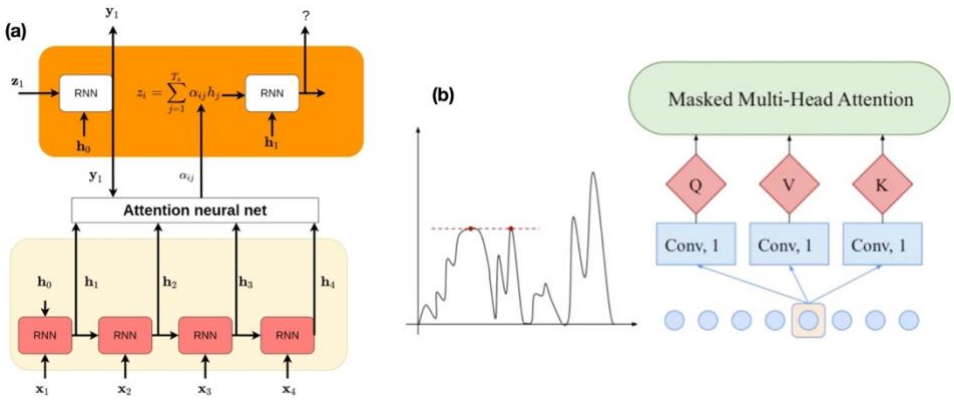

Figure. Time-series coupled with attention neural network.
(a) Structure of RNN network and attention network. (b) Multi-Head attention applied to sequence [3].

Research Topic: Batteries are a crucial component of modern society so optimizing their performance and lifespan is a crucial step for the energy transition, and with the improvements of Artificial Intelligence it became a reliable tool to analyze and predict the mechanism of degradation in the battery **[1]**.

In deep learning, analyzing time series data shares similarities with Natural Language Processing (NLP). In this research, we aim to leverage techniques successful in NLP and apply them to time series analysis for battery systems **[2]**.

The initial step involves the use of “embedding”, a technique that transforms words into vectors in NLP. In the context of time series, this embedding will act as a feature extraction method. Here, we'll represent time series data points as vectors. For this embedding process, we'll explore models based on Long Short-Term Memory (LSTM) or Convolutional Neural Networks (CNN).

The subsequent phase introduces the “attention” mechanism **[3]**. In NLP, attention helps correlate different parts of text for improved context understanding. Similarly, for time series, the attention mechanism will identify and weigh the importance of various data points in relation to others, enhancing our model's understanding of the data. This helps to combine information extracted in the embedding phase with other relevant data.

Limitations of this tile-series attention approach will be addressed in this study. Recurrent networks with attention mechanisms offer great promise in time series analysis but come with challenges. Their computational complexity can lead to long training times, especially on extensive datasets. Despite being designed to manage sequence data, they can overfit on limited data and struggle with extremely long sequences. They operate on the assumption of sequence continuity, which might not always hold true. Lastly, attention mechanisms might not always capture very long-term dependencies effectively.

Finally, the processed data will be passed to an output layer, which initially might be a dense layer, translating the processed features into meaningful predictions. Depending on progress and results, we may also explore implementing a “transformer” model, a more advanced architecture known for its efficacy in NLP, to enhance prediction accuracy **[4]**.

The candidate will work within the Image, Diffraction & DataScience (I&2D) team in LRCS lab leading by Dr. Arnaud Demortière, CNRS researcher. The internship will be under the supervision of Dr. A. Demortière and Florent Magaud (PhD student).

References: **[1]** Che, Yunhong and Hu, Xiaosong and Lin, Xianke and Guo, Jia and Teodorescu, Remus, "Health prognostics for lithium-ion batteries: mechanisms, methods, and prospects" in Energy Environ. Sci., vol. 16,no. 2, pp. 338-371, 2023, doi :10.1039/D2EE03019E**.** **[2]** K. Park, Y. Choi, W. J. Choi, H. -Y. Ryu and H. Kim, "LSTM-Based Battery Remaining Useful Life Prediction With Multi-Channel Charging Profiles," in *IEEE Access*, vol. 8, pp. 20786-20798, 2020, doi: 10.1109/ACCESS.2020.2968939. **[3]** Zhaoyang Niu, Guoqiang Zhong, Hui Yu,”A review on the attention mechanism of deep learning”, Neurocomputing, Volume 452, 2021, Pages 48-62, ISSN 0925-2312, https://doi.org/10.1016/j.neucom.2021.03.091. **[4]** Vaswani, A.; Shazeer, N. M.; Parmar, N.; Uszkoreit, J.; Jones, L.; Gomez, A. N.; Kaiser, L.; Polosukhin, I. Attention is all you need. In: Proceedings of the 31st International Conference on Neural Information Processing System, 6000–6010, 2017.