Anomaly Localization in Industrial Internet of Things via Temporal Graph Auto-Encoders

Postdoctoral position - 1 year, starting in Februrary 2026

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Context. The Industrial Internet of Things (IIoT) is a rapidly evolving paradigm in which industrial sensors, machines, and other instruments are connected to the internet, enabling device-to-server and device-to-device communications for real-time data exchange. IIoT systems produce two types of data where detecting anomalies is crucial: (i) device communication logs and (ii) device measurements. For the former, devices are now exposed to attacks or intrusions, thus making it necessary to search for signs of these events in the communication logs. For the latter, any equipment or operational issues will lead to changes in IIoT measurements and potentially critical production shutdowns, making it vital to promptly detect these events to trigger corrective actions.

A natural model for IIoT data are attributed weighted temporal graphs: nodes represent devices; node features represent their measurements; and time-varying weighted edges capture various types of information, such as their communications, their statistical dependencies, flows through them, etc. In the initial phase of this project, we have already developed powerful temporal graph-based auto-encoder models capable of detecting both temporal and structural anomalies in IIoT. See Figure 1 for an illustration. Yet, while our auto-encoder models allow us to ***detect*** the presence of an anomaly, they are still unable to ***localize*** the anomaly.

The main goal of this postdoctoral project is to fundamentally extend our temporal graph auto-encoder models beyond anomaly detection to perform anomaly localization.

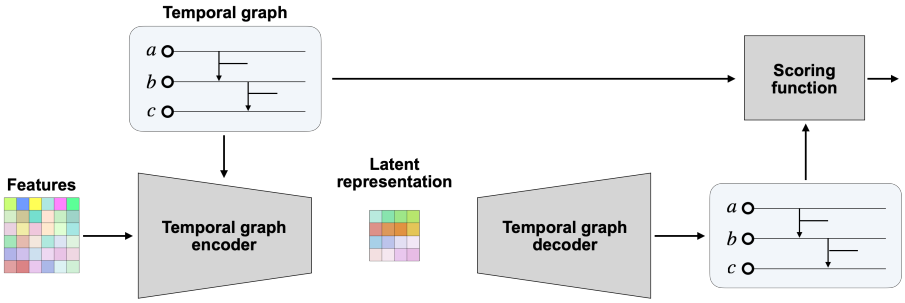

Figure 1: A temporal graph-based auto-encoder architecture for anomaly detection.

Goals. The recruited postdoc will have the two main goals.

1. **Extension of Auto-Encoders for Anomaly Localization.** Our models currently receive a temporal graph as input and produce an anomaly score that is proportional to the scope of its abnormal events [1]. Thus, they maximize their scores if run only on the anomalous sub-temporal graphs (which are temporal graphs). While this can be used to localize anomalies (by searching for the subset maximizing the anomaly score), it is impractical due to the exponential number of subsets to test. Our aim is to prune-down the search space by properly structuring the auto-encoder's latent representation, so that sub-graphs map to sub-spaces of

its containing graph. This will require substantial architectural innovation to disentangle the auto-encoder's structured representation and achieve fine-grained anomaly localization. We intend to leverage techniques that have proven successful in other domains to structure the latent space [4, 2] and recent developments in neural models for sub-graph search problems [6, 7].

2. **Application to IIoT logs and measurements.** We aim to evaluate the methodological developments above in real-world IIoT dataset that contain various types of attacks (structural anomalies) and measurement faults (feature anomalies) [3, 5]. We aim to explore the advantages of our approach in real-world, potentially online, scenarios, such as machine health monitoring, transportation network monitoring, or other use cases that may arise from collaborations with local companies.

Profile. We look for highly motivated candidates with relevant experience in anomaly detection, graph machine learning, and/or deep learning. Experience in Python programming, cybersecurity and/or streaming algorithms is a plus. Ideal candidates will have a publication record in selective AI conferences.

Application. Interested candidates are invited to send a cover letter, a detailed CV (with a publication list and the contact details of two references), and their PhD manuscript or a recent paper to:

- Esteban Bautista: esteban.bautista@univ-littoral.fr
- Claire Guilloteau: claire.guilloteau@univ-littoral.fr

Applications will be reviewed on a rolling basis until the position is filled.

References

[1] E. Bautista, et al. *MAD: Multi-Scale Anomaly Detection in Link Streams.* Proceedings of the 17th ACM International Conference on Web Search and Data Mining. 2024.

[2] E. Bautista et al., *Link Streams as a Generalization of Graphs and Time Series*. In 2023 IEEE 5th International Conference on Cognitive Machine Intelligence (CogMI), pp. 150-158, 2023.

[3] Y. Wu, et al., *Graph Neural Networks for Anomaly Detection in Industrial Internet of Things*. IEEE Internet Things J., vol. 9, no. 12, pp. 9214–9231, Jun. 2022.

[4] C. Guilloteau, et al., *Generative Networks for emulating synthetic sky images*. Kavli Summer Program in Astrophysics, 2019.

[5] Z. Chen et al., *Graph neural network-based fault diagnosis: a review*, arXiv: arXiv:2111.08185. Nov. 15, 2021.

[6] N. Karalias, et al., *Erdos goes neural: an unsupervised learning framework for combinatorial optimization on graphs.*. Advances in Neural Information Processing Systems 33, 2020.

[7] Q. Cappart, et al., *Combinatorial optimization and reasoning with graph neural networks.* Journal of Machine Learning Research, 2023.