Jiayi GUI, Zhongnan MA, Hao ZHOU, et al., 2025. Deep anomaly detection of temporal heterogeneous data in AIOps: a survey. *Frontiers of Information Technology & Electronic Engineering*, 26(9):1551-1576.
https://doi.org/10.1631/FITEE.2400467

Deep anomaly detection of temporal heterogeneous data in AIOps: a survey

Key words: Anomaly detection; AIOps; Large language models; Communications networks

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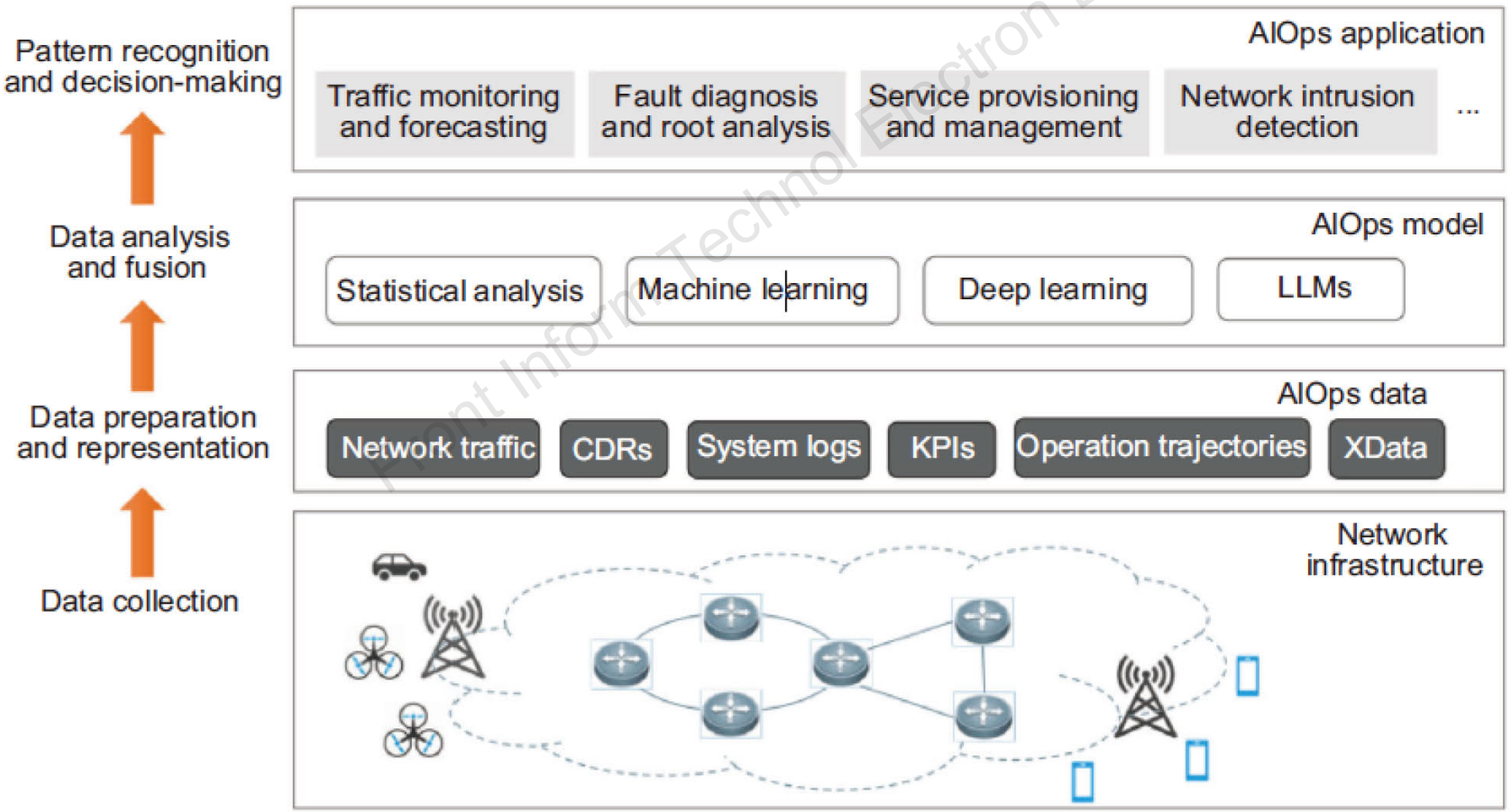
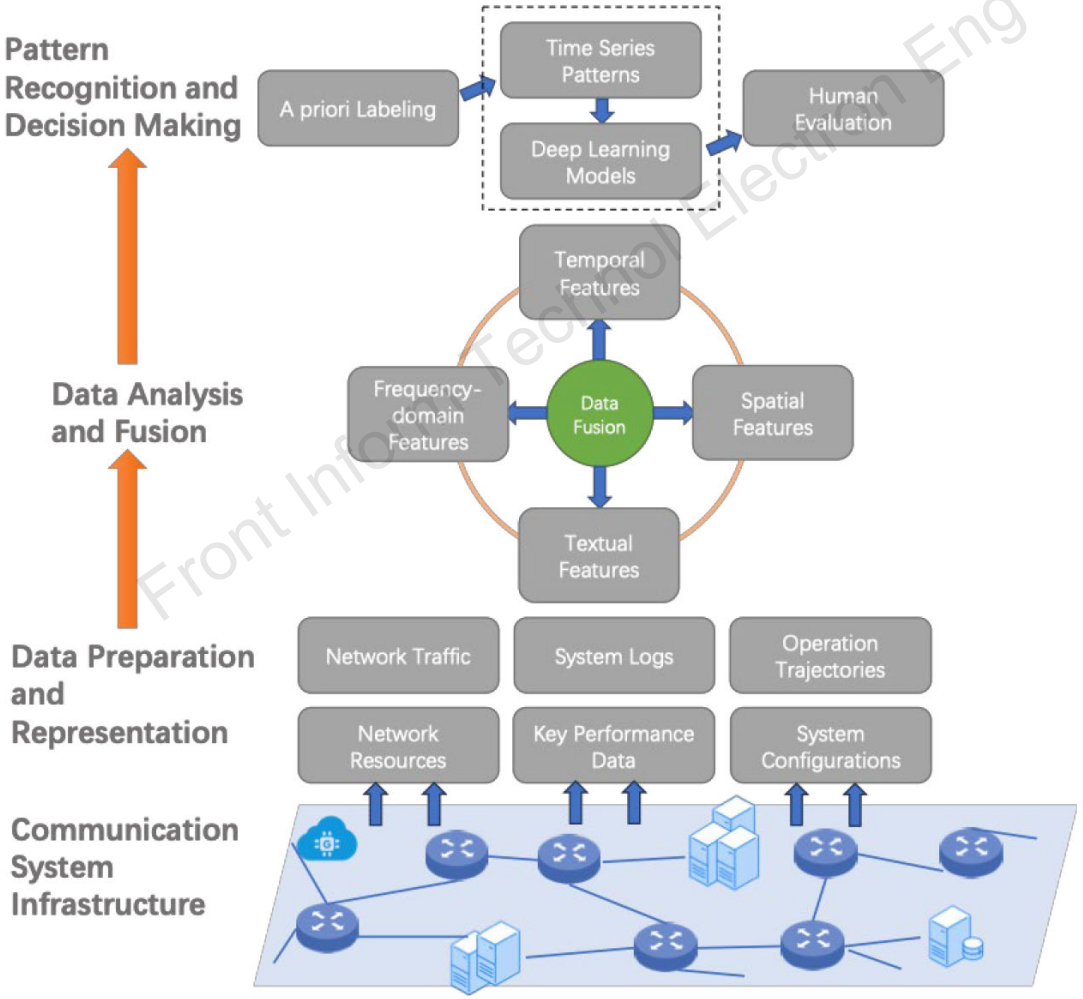
AIOps framework

- The concept of artificial intelligence for information technology operations (AIOps) has been proposed to manage the complexity and scale of modern Internet systems.



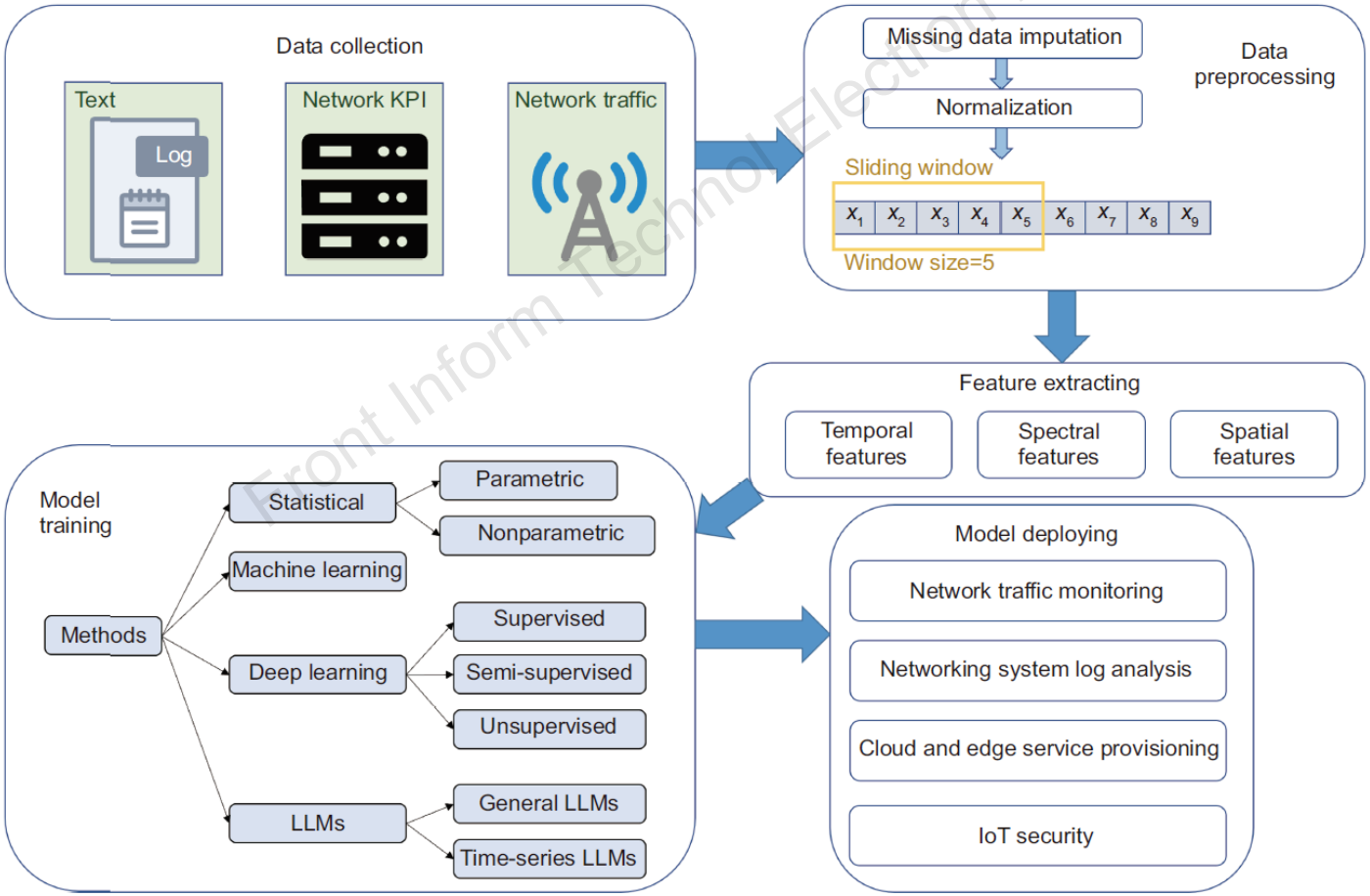
AIOps framework

- The advancement of 5G and Internet of Things (IoT) has enabled intelligent applications, but also made networks more complex and vulnerable to targeted attacks.



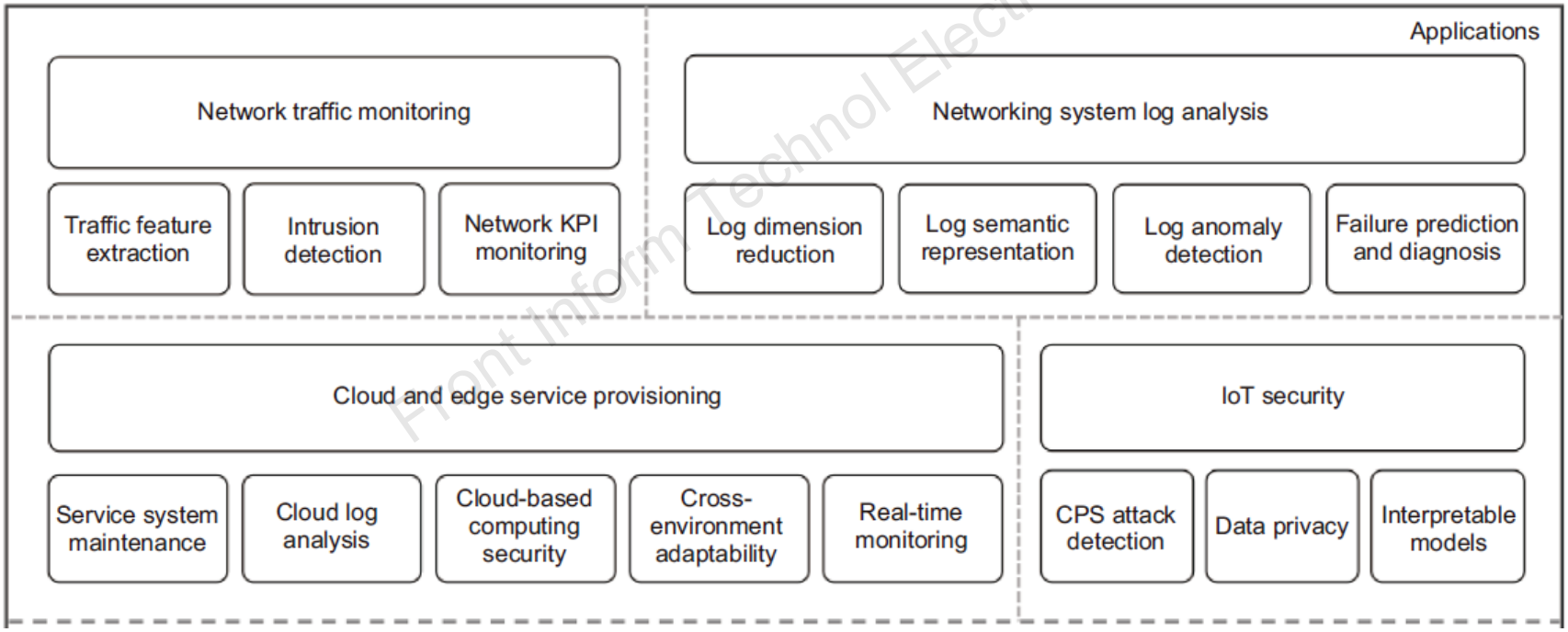
AIOps pipeline

- The pipeline of AIOps in the communication network can be divided into the following five stages: data collection, data preprocessing, feature extracting, model training, and model deploying.



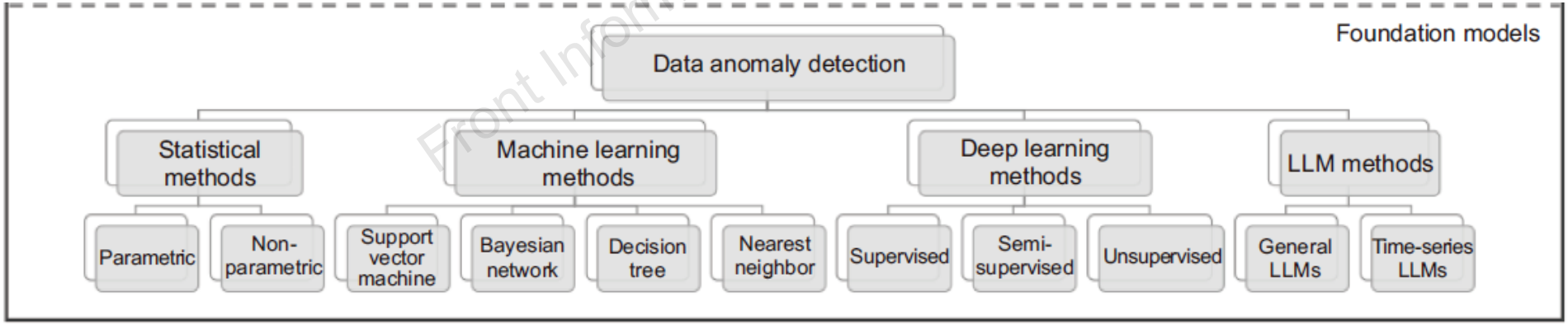
Scope

- Our survey covers four application domains: network traffic monitoring, network system log analysis, cloud and edge service provisioning, and IoT security.



Methodology

- Our survey categorizes anomaly detection (AD) methods into four main categories as follows: statistical methods (parametric and nonparametric), machine learning methods (support vector machine, Bayesian network, decision tree, and the nearest neighbor), deep learning methods (supervised, semi-supervised, and unsupervised), and large language model (LLM) methods (general LLMs and time-series LLMs).



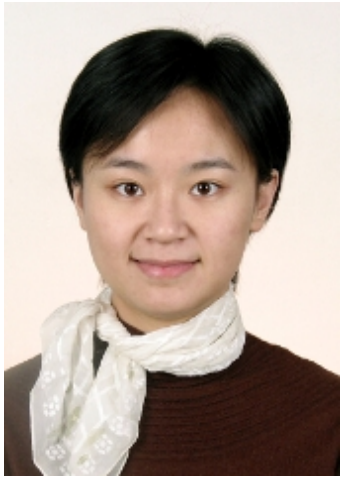
Methods in different application domains

Domain	Method
Networking traffic monitoring	SGmVRNN (Dai et al., 2022), D-PACK (Hwang et al., 2020), MSRC (Duan et al., 2023), LSTM-GAN-G (Huang et al., 2022), RENOIR (Andresini et al., 2021), CMAE (Lu et al., 2022), ARCADE (Lunardi et al., 2023), APAE (Basati and Faghih, 2023), DCNNBiLSTM (Hnamte and Hussain, 2023), CANET (Ren KY et al., 2023)
Networking system log analysis	LogPrompt (Liu YL et al., 2024), DeepLog (Du M et al., 2017), LogAnomaly (Meng et al., 2019), PLELog (Yang L et al., 2021), LogRobust (Zhang X et al., 2019b)
IoT security	NSIBF (Feng and Tian, 2021), GAN-AD (Li D et al., 2019a), MAE and MDAE (Vu et al., 2022), N-BaIoT (Meidan et al., 2018), FDL (Popoola et al., 2022), FeCo (Wang et al., 2022), FedPG (Nguyen et al., 2023)
Cloud and edge service provisioning	LogNL (Zhu et al., 2020), GLLD (Khalaf et al., 2022), CGNN-MHSA-AR (Song YJ et al., 2023)

Future outlook

Future direction	Outlook
Robustness	• Enhancing robustness to address concept drift and class imbalance in communication systems • Developing AD systems resistant to adversarial attacks • Robust AD in dynamic and evolving communication networks
Explainability	• Enhancing explainability to address nonstationary and concept drift • Standardization of explainability metrics • Tailoring explanations to different stakeholders
LLM applications	• Leveraging LLMs to address AD challenges in communication systems • Training tailored LLMs for time series • Addressing resource intensity in time-series LLMs for AD

Author bio



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