Supplementary Material

Bruna Alves[1*], Armando J. Pinho[1] and Sónia Gouveia[1*]

[1*]IEETA/DETI/LASI, University of Aveiro, 3810-193, Aveiro, Portugal.

*Corresponding author(s). E-mail(s): bruna.alves@ua.pt;
sonia.gouveia@ua.pt;
Contributing authors: ap@ua.pt;

Abstract

This document presents the full list of papers analyzed in this review, divided into three categories: 409 Categorized Papers (2019-2024), 12 Selected Reviews or Evaluation Papers (2019-2024) and 190 Validation Papers (2025). The 409 Categorized Papers (2019-2024) correspond to the categorized paers using the unified taxonomy. The 12 Selected Reviews or Evaluation Papers (2019-2024) comprise reviews papers as well as evaluation papers, which support the empirical development of the proposed taxonomy. The 190 Validation Papers (2025) is the set of papers retrieved from 2025 that were used to validate the taxonomy, confirming its relevance and adaptability to ongoing developments in the field.

409 Categorized Papers (2019-2024)

[Cat1] Abdan Mulia M, Bahy MB, Siswantoro MZFN, et al (2024) KBJNet: Kinematic bi-joint temporal convolutional network attention for anomaly detection in multivariate time series data. Data Sci J 23. https://doi.org/10.5334/dsj-2024-010

[Cat2] Abdulaal A, Liu Z, Lancewicki T (2021) Practical approach to asynchronous multivariate time series anomaly detection and localization. In: Proc. ACM SIGKDD Int. Conf. Knowl. Discov. Data Min. (KDD'21), pp 2485–2494, https://doi.org/10.1145/3447548.3467174

[Cat3] Ahmad A, Kovalenko A, Makarov I (2024) Anomaly detection using graph-based autoencoder with graph structure learning layer. In: IEEE Int. Symp. Logist. Ind. Informat. (LINDI'24), pp 89–94, https://doi.org/10.1109/LINDI63813.2024.10820392

[Cat4] Akbarian H, Mahgoub I, Williams A (2024) Autoencoder-K-means algorithm for efficient anomaly detection to improve space operations. In: IEEE Int. Conf. Smart Appl. Commun. Netw. (SmartNets'24), pp 1–6, https://doi.org/10.1109/SmartNets61466.2024.10577704

[Cat5] Audibert J, Michiardi P, Guyard F, et al (2020) USAD: Unsupervised anomaly detection on multivariate time series. In: Proc. ACM SIGKDD Int. Conf. Knowl. Discov. Data Min. (KDD'20), pp 3395–3404, https://doi.org/10.1145/3394486.3403392

[Cat6] Bai Y, Wang J, Zhang X, et al (2023) CrossFuN: Multiview joint cross-fusion network for time-series anomaly detection. IEEE Trans Instrum Meas 72:1–9. https://doi.org/10.1109/tim.2023.3315420

[Cat7] Bao J, Gao H, Zhang C, et al (2024) A multi-scale parallel unsupervised model for multivariate time series anomaly detection. In: Artif. Intell. Appl. Innov. (AIAI'24), pp 241–251

[Cat8] Bashar MA, Nayak R (2020) Tanogan: Time series anomaly detection with generative adversarial networks. In: IEEE Symp. Ser. Comput. Intell. (SSCI'20), pp 1778–1785, https://doi.org/10.1109/SSCI47803.2020.9308512

[Cat9] Behrouz A, Santacatterina M, Zabih R (2024) Chimera: Effectively modeling multivariate time series with 2-dimensional state space models. In: Adv. Neural Inf. Process. Syst. (NeurIPS'24), pp 119886–119918, https://doi.org/10.52202/079017-3810

[Cat10] Brockmann JT, Rudolph M, Rosenhahn B, et al (2024) The voraus-AD dataset for anomaly detection in robot applications. IEEE Trans Robot 40:438–451. https://doi.org/10.1109/tro.2023.3332224

[Cat11] Campos D, Kieu T, Guo C, et al (2021) Unsupervised time series outlier detection with diversity-driven convolutional ensembles. Proc VLDB Endow 15(3):611–623. https://doi.org/10.14778/3494124.3494142, URL https://doi.org/10.14778/3494124.3494142

[Cat12] Cao D, Liu D, Ren X, et al (2021) Self-adaption aae-gan for aluminum electrolytic cell anomaly detection. IEEE Access 9:100991–101002. https://doi.org/10.1109/ACCESS.2021.3097116

[Cat13] Cao Y, Yan J, Feng H, et al (2023) SCAAE: Using self-supervised contrastive learning in adversarial autoencoder for anomaly detection of multivariate time series in cyber physics systems. In: IEEE China Autom. Congr. (CAC'23), pp 8102–8107, https://doi.org/10.1109/CAC59555.2023.10451988

[Cat14] Carmona CU, Aubet FX, Flunkert V, et al (2022) Neural contextual anomaly detection for time series. In: Proc. Int. Jt. Conf. Artif. Intell. (IJCAI'22), pp 2843–2851, https://doi.org/10.24963/ijcai.2022/394

[Cat15] Challu CI, Jiang P, Nian Wu Y, et al (2022) Deep generative model with hierarchical latent factors for time series anomaly detection. In: Int. Conf. Artif. Intell. Stat. (AISTATS'22), pp 1643–1654, URL https://proceedings.mlr.press/v151/challu22a.html

[Cat16] Chambaret G, Berti-Equille L, Bouchara F, et al (2022) Stochastic pairing for contrastive anomaly detection on time series. In: Pattern Recognit. Artif. Intell. (ICPRAI'22), p 306–317, https://doi.org/10.1007/978-3-031-09282-4_26

[Cat17] Chen B, Lu H, Chen Y, et al (2023a) DGNN: Dynamic graph neural networks for anomaly detection in multivariate time series. In: Proc. Int. Conf. Softw. Eng. Knowl. Eng. (SEKE'23), pp 415–420, https://doi.org/10.18293/SEKE2023-094

[Cat18] Chen H, Li X, Liu W (2024a) Multivariate time series anomaly detection by fusion of deep convolution residual autoencoding reconstruction model and ConvLstm forecasting model. Comput Secur 137. https://doi.org/10.1016/j.cose.2023.103581

[Cat19] Chen J, Pi D, Wang X (2024b) A two-stage adversarial transformer based approach for multivariate industrial time series anomaly detection. Appl Intell 54(5):4210–4229. https://doi.org/10.1007/s10489-024-05395-0

[Cat20] Chen K, Zhao G, Yao Z, et al (2023b) STAD: Multivariate time series anomaly detection based on spatio-temporal relationship. In: Adv. Data Min. Appl. (ADMA'23), p 73–87, https://doi.org/10.1007/978-3-031-46661-8_6

[Cat21] Chen N, Tu H, Duan X, et al (2022a) Semisupervised anomaly detection of multivariate time series based on a variational autoencoder. Appl Intell 53:6074–6098. https://doi.org/10.1007/s10489-022-03829-1

[Cat22] Chen N, Tu H, Zeng H, et al (2024c) Anomaly detection for key performance indicators by fusing self-supervised spatio-temporal graph attention networks. Knowl-Based Syst 300. https://doi.org/10.1016/j.knosys.2024.112167

[Cat23] Chen S, Xu F, Wen P, et al (2022b) A multivariate time series anomaly detection method based on generative model. In: IEEE Int. Conf. Progn. Health Manag. (ICPHM'22), pp 137–144, https://doi.org/10.1109/ICPHM53196.2022.9815702

[Cat24] Chen S, Yan D, He X (2024d) MTS anomaly detection based on temporal and feature correlation. In: IEEE Chin. Control Conf. (CCC'24), pp 5032–5037, https://doi.org/10.23919/CCC63176.2024.10662146

[Cat25] Chen T, Liu X, Xia B, et al (2020) Unsupervised anomaly detection of industrial robots using sliding-window convolutional variational autoencoder. IEEE Access

8:47072–47081. https://doi.org/10.1109/ACCESS.2020.2977892

[Cat26] Chen W, Tian L, Chen B, et al (2022c) Deep variational graph convolutional recurrent network for multivariate time series anomaly detection. In: Proc. Int. Conf. Mach. Learn. (ICML'22), pp 3621–3633, URL https://proceedings.mlr.press/v162/chen22x.html

[Cat27] Chen X, Deng L, Huang F, et al (2021) DAEMON: Unsupervised anomaly detection and interpretation for multivariate time series. In: IEEE Int. Conf. Data Eng. (ICDE'21), pp 2225–2230, https://doi.org/10.1109/ICDE51399.2021.00228

[Cat28] Chen X, Qiu Q, Li C, et al (2022d) Graphad: A graph neural network for entity-wise multivariate time-series anomaly detection. In: Proc. Int. ACM SIGIR Conf. Res. Dev. Inf. Retr., SIGIR '22, pp 2297–2302, https://doi.org/10.1145/3477495.3531848

[Cat29] Chen Y, Zhang C, Ma M, et al (2023c) ImDiffusion: Imputed diffusion models for multivariate time series anomaly detection. Proc VLDB Endow 17(3):359–372. https://doi.org/10.14778/3632093.3632101

[Cat30] Chen Z, Chen D, Zhang X, et al (2022e) Learning graph structures with transformer for multivariate time-series anomaly detection in iot. IEEE Internet Things J 9(12):9179–9189. https://doi.org/10.1109/jiot.2021.3100509

[Cat31] Chen Z, Yu J, Tan Q, et al (2024e) DGTAD: decomposition GAN-based transformer for anomaly detection in multivariate time series data. Appl Intell 54(24):13038–13056. https://doi.org/10.1007/s10489-024-05693-7

[Cat32] Chevrot A, Vernotte A, Legeard B (2022) CAE: Contextual auto-encoder for multivariate time-series anomaly detection in air transportation. Comput Secur 116. https://doi.org/https://doi.org/10.1016/j.cose.2022.102652

[Cat33] Choi H, Kim S, Kang P (2023) Recurrent auto-encoder with multi-resolution ensemble and predictive coding for multivariate time-series anomaly detection. Appl Intell 53(21):25330–25342. https://doi.org/10.1007/s10489-023-04764-5

[Cat34] Choi T, Lee D, Jung Y, et al (2022) Multivariate time-series anomaly detection using SeqVAE-CNN hybrid model. In: IEEE Int. Conf. Inf. Netw. (ICOIN'22), pp 250–253, https://doi.org/10.1109/ICOIN53446.2022.9687205

[Cat35] Choi Y, Lim H, Choi H, et al (2020) GAN-based anomaly detection and localization of multivariate time series data for power plant. In: IEEE Int. Conf. Big Data Smart Comput. (BigComp'20), pp 71–74, https://doi.org/10.1109/BigComp48618.2020.00-97

[Cat36] Correia L, Goos J, Klein P, et al (2023) MA-VAE: Multi-head attention-based variational autoencoder approach for anomaly detection in multivariate time-series

applied to automotive endurance powertrain testing. In: Proc. Int. Jt. Conf. Comput. Intell. (NCTA'23), pp 407–418, https://doi.org/10.5220/0012163100003595

[Cat37] Cui T, Liu Y, Zhu Y (2024a) A graph recurrent attention network for multivariate time series anomaly detection. In: IEEE Int. Conf. Mach. Learn. Intell. Syst. Eng. (MLISE'24), pp 57–62, https://doi.org/10.1109/MLISE62164.2024.10674110

[Cat38] Cui T, Zhu Y, Liu Y, et al (2024b) Time series anomaly detection using temporal 2d-variation multi-layer feature fusion times network. In: IEEE Int. Conf. Cyber Technol. Autom. Control Intell. Syst. (CYBER'24), pp 726–731, https://doi.org/10.1109/CYBER63482.2024.10748873

[Cat39] Dai E, Chen J (2022) Graph-augmented normalizing flows for anomaly detection of multiple time series. In: Int. Conf. Learn. Represent. (ICLR'22), URL https://openreview.net/forum?id=45L_dgP48Vd

[Cat40] Dai Z, He L, Yang SH, et al (2024) SARAD: Spatial association-aware anomaly detection and diagnosis for multivariate time series. In: Adv. Neural Inf. Process. Syst. (NeurIPS'24), pp 48371–48410, https://doi.org/10.52202/079017-1533

[Cat41] Dairi A, Cheng T, Harrou F, et al (2019) Deep learning approach for sustainable wwtp operation: A case study on data-driven influent conditions monitoring. Sustain Cities Soc 50. https://doi.org/https://doi.org/10.1016/j.scs.2019.101670

[Cat42] De Vita F, Nocera G, Bruneo D, et al (2023) A novel echo state network autoencoder for anomaly detection in industrial iot systems. IEEE Trans Ind Informat 19(8):8985–8994. https://doi.org/10.1109/TII.2022.3224981

[Cat43] Deng A, Hooi B (2021) Graph neural network-based anomaly detection in multivariate time series. In: Proc. AAAI Conf. Artif. Intell. (AAAI'21), pp 4027–4035, https://doi.org/10.1609/aaai.v35i5.16523

[Cat44] Deng L, Chen X, Zhao Y, et al (2021) HIFI: Anomaly detection for multivariate time series with high-order feature interactions. In: Database Syst. Adv. Appl. (DASFAA'21), pp 641–649

[Cat45] Ding C, Sun S, Zhao J (2023a) MST-GAT: A multimodal spatial–temporal graph attention network for time series anomaly detection. Inf Fusion 89:527–536. https://doi.org/10.1016/j.inffus.2022.08.011

[Cat46] Ding G, Zhu Y, Ren Y (2024) Dynamic-static fusion for spatial-temporal anomaly detection and interpretation in multivariate time series. In: Web and Big Data (APWeb-WAIM'24), p 46–61, https://doi.org/10.1007/978-981-97-7238-4_4

[Cat47] Ding N, Ma H, Gao H, et al (2019) Real-time anomaly detection based on long short-term memory and gaussian mixture model. Comput Electr Eng 79. https://doi.org/10.1016/j.compeleceng.2019.106458

[Cat48] Ding X, Liu Y, Wang H, et al (2023b) SNN-AAD: Active anomaly detection method for multivariate time series with sparse neural network. In: Database Syst. Adv. Appl. (DASFAA'23), p 253–269, https://doi.org/10.1007/978-3-031-30637-2_17

[Cat49] Dong X, Liu H, Du J, et al (2024) Online multivariate time series anomaly detection method based on contrastive learning. In: Adv. Intell. Comput. Technol. Appl. (ICIC'24), pp 468–479

[Cat50] Dong Z, Liu K, Han D, et al (2022) Reconstruction-based multi-scale anomaly detection for cyber-physical systems. In: IEEE Int. Conf. Ind. Artif. Intell. (IAI'22), pp 1–6, https://doi.org/10.1109/IAI55780.2022.9976844

[Cat51] Du B, Sun X, Ye J, et al (2023) GAN-based anomaly detection for multivariate time series using polluted training set. IEEE Trans Knowl Data Eng 35(12):12208–12219. https://doi.org/10.1109/TKDE.2021.3128667

[Cat52] Duan Y, Xiang M, Zhou B, et al (2022) TCAD: Unsupervised anomaly detection based on global local representation differences. IEEE Access 10:114683–114693. https://doi.org/10.1109/ACCESS.2022.3216930

[Cat53] El-Shafeiy E, Alsabaan M, Ibrahem MI, et al (2023) Real-time anomaly detection for water quality sensor monitoring based on multivariate deep learning technique. Sensors 23(20). https://doi.org/10.3390/s23208613

[Cat54] Elhalwagy A, Kalganova T (2022) Multi-channel LSTM-capsule autoencoder network for anomaly detection on multivariate data. Appl Sci 12(22). https://doi.org/10.3390/app122211393

[Cat55] Fährmann D, Damer N, Kirchbuchner F, et al (2022) Lightweight long short-term memory variational auto-encoder for multivariate time series anomaly detection in industrial control systems. Sensors 22(8). https://doi.org/10.3390/s22082886

[Cat56] Fan J, Liu Z, Wu H, et al (2023a) LUAD: A lightweight unsupervised anomaly detection scheme for multivariate time series data. Neurocomputing 557. https://doi.org/10.1016/j.neucom.2023.126644

[Cat57] Fan J, Wang Z, Wu H, et al (2023b) An adversarial time–frequency reconstruction network for unsupervised anomaly detection. Neural Netw 168:44–56. https://doi.org/10.1016/j.neunet.2023.09.018

[Cat58] Feng C, Tian P (2021) Time series anomaly detection for cyber-physical systems via neural system identification and bayesian filtering. In: Proc. ACM SIGKDD Int. Conf. Knowl. Discov. Data Min. (KDD'21), p 2858–2867, https://doi.org/10.1145/3447548.3467137

[Cat59] Feng X, Jiang X, Sun Y, et al (2023a) An anomaly detection method for multivariate time series based on cross window. In: IEEE Int. Conf. Comput. Support. Coop. Work Des. (CSCWD'23), pp 399–404, https://doi.org/10.1109/CSCWD57460.2023.10152583

[Cat60] Feng Y, Chen J, Liu Z, et al (2022) Full graph autoencoder for one-class group anomaly detection of iiot system. IEEE Internet Things J 9(21):21886–21898. https://doi.org/10.1109/JIOT.2022.3181737

[Cat61] Feng Y, Liu Z, Chen J, et al (2023b) Unsupervised multimodal anomaly detection with missing sources for liquid rocket engine. IEEE Trans Neural Netw Learn Syst 34(12):9966–9980. https://doi.org/10.1109/TNNLS.2022.3162949

[Cat62] Feng Y, Zhang W, Fu Y, et al (2024a) SensitiveHUE: Multivariate time series anomaly detection by enhancing the sensitivity to normal patterns. In: Proc. ACM SIGKDD Int. Conf. Knowl. Discov. Data Min. (KDD'24), p 782–793, https://doi.org/10.1145/3637528.3671919

[Cat63] Feng Y, Zhang W, Sun H, et al (2024b) Spatial-temporal transformer with error-restricted variance estimation for time series anomaly detection. In: Adv. Knowl. Discov. Data Min. (PAKDD'24), LNCS, vol 14645. Springer Nature Singapore, p 3–14, https://doi.org/10.1007/978-981-97-2242-6_1

[Cat64] Fraikin AF, Bennetot A, Allassonniere S (2024) T-Rep: Representation learning for time series using time-embeddings. In: Int. Conf. Learn. Represent. (ICLR'24), URL https://openreview.net/forum?id=3y2TfP966N

[Cat65] Fu S, Gao X, Li B, et al (2024a) Multivariate time series anomaly detection via separation, decomposition, and dual transformer-based autoencoder. Appl Soft Comput 159. https://doi.org/https://doi.org/10.1016/j.asoc.2024.111671

[Cat66] Fu S, Gao X, Zhai F, et al (2024b) A time series anomaly detection method based on series-parallel transformers with spatial and temporal association discrepancies. Inf Sci 657. https://doi.org/10.1016/j.ins.2023.119978

[Cat67] Gao R, He W, Yan L, et al (2023) Hybrid graph transformer networks for multivariate time series anomaly detection. J Supercomput 80(1):642–669. https://doi.org/10.1007/s11227-023-05503-w

[Cat68] Ge D, Cheng Y, Cao S, et al (2024a) An enhanced abnormal information expression spatiotemporal model for anomaly detection in multivariate time-series. Complex Intell Syst 10(2):2937–2950. https://doi.org/10.1007/s40747-023-01306-x

[Cat69] Ge D, Dong Z, Cheng Y, et al (2024b) An enhanced spatio-temporal constraints network for anomaly detection in multivariate time series. Knowl-Based Syst 283. https://doi.org/10.1016/j.knosys.2023.111169

[Cat70] Ge N, Weng X, Yang Q (2022) Unsupervised anomaly detection via two-dimensional singular value decomposition and subspace reconstruction for multivariate time series. Appl Intell 53(13):16813–16829. https://doi.org/10.1007/s10489-022-04337-y

[Cat71] Giannoulis M, Harris A, Barra V (2023) DITAN: A deep-learning domain agnostic framework for detection and interpretation of temporally-based multivariate anomalies. Pattern Recognit 143. https://doi.org/10.1016/j.patcog.2023.109814

[Cat72] Gong S, Wu Z, Liu Y, et al (2021) A prediction-augmented autoencoder for multivariate time series anomaly detection. In: Neural Inf. Process. (ICONIP'21), p 681–692, https://doi.org/10.1007/978-3-030-92185-9_56

[Cat73] González GG, Tagliafico SM, Iie-Fing AF, et al (2022) DC-VAE, fine-grained anomaly detection in multivariate time-series with dilated convolutions and variational auto encoders. In: IEEE Eur. Symp. Secur. Priv. Workshops (EuroS&PW'22), pp 287–293, https://doi.org/10.1109/EuroSPW55150.2022.00035

[Cat74] Gorbett M, Shirazi H, Ray I (2023) Sparse binary transformers for multivariate time series modeling. In: Proc. ACM SIGKDD Int. Conf. Knowl. Discov. Data Min. (KDD'23), p 544–556, https://doi.org/10.1145/3580305.3599508

[Cat75] Goswami U, Rani J, Kodamana H, et al (2023) Fault detection and isolation of multi-variate time series data using spectral weighted graph auto-encoders. J Franklin Inst 360(10):6783–6803. https://doi.org/10.1016/j.jfranklin.2023.04.030

[Cat76] Guan S, Zhao B, Dong Z, et al (2022) GTAD: Graph and temporal neural network for multivariate time series anomaly detection. Entropy 24(6). https://doi.org/10.3390/e24060759

[Cat77] Guan S, He Z, Ma S, et al (2023) Conditional normalizing flow for multivariate time series anomaly detection. ISA Trans 143:231–243. https://doi.org/10.1016/j.isatra.2023.09.002

[Cat78] Guan S, He Z, Ma S, et al (2024) Multivariate time series anomaly detection with variational autoencoder and spatial–temporal graph network. Comput Secur 142. https://doi.org/https://doi.org/10.1016/j.cose.2024.103877

[Cat79] Guo H, Zhou Z, Zhao D (2023a) GNN-Based energy-efficient anomaly detection for iot multivariate time-series data. In: IEEE Int. Conf. Commun. (ICC'23), pp 2492–2497, https://doi.org/10.1109/ICC45041.2023.10278988

[Cat80] Guo H, Zhou Z, Zhao D, et al (2024) EGNN: Energy-efficient anomaly detection for iot multivariate time series data using graph neural network. Future Gener Comput Syst 151:45–56. https://doi.org/10.1016/j.future.2023.09.028

[Cat81] Guo Q, Zhang J, Chen Y, et al (2023b) Multivariate time series anomaly detection in a regularization perspective. In: Proc. ACM Int. Conf. Comput. Artif. Intell. (ICCAI'23), p 279–287, https://doi.org/10.1145/3594315.3594655

[Cat82] Han CS, Lee KM (2023) Hybrid deep learning model for time series anomaly detection. In: Proc. ACM Int. Conf. Res. Adapt. Converg. Syst. (RACS'23), https://doi.org/10.1145/3599957.3606232

[Cat83] Han Q, Chen J, Wang J, et al (2024) Complex system anomaly detection via learnable temporal-spatial graph with degradation tendency segmentation. ISA Trans 152:156–166. https://doi.org/10.1016/j.isatra.2024.06.025

[Cat84] Han S, Woo SS (2022) Learning sparse latent graph representations for anomaly detection in multivariate time series. In: Proc. ACM SIGKDD Int. Conf. Knowl. Discov. Data Min. (KDD '22), pp 2977–2986, https://doi.org/https://doi.org/10.1145/3534678.3539117

[Cat85] Hashimoto M, Ide Y, Aritsugi M (2021) Anomaly detection for sensor data of semiconductor manufacturing equipment using a gan. Procedia Comput Sci 192:873–882. https://doi.org/https://doi.org/10.1016/j.procs.2021.08.090

[Cat86] He H, Li X, Chen P, et al (2024a) DGFormer: An effective dynamic graph transformer based anomaly detection model for iot time series. In: Collabor. Comput. Netw. Appl. Worksharing (CollaborateCom'23), p 173–188, https://doi.org/10.1007/978-3-031-54528-3_10

[Cat87] He J, Dong M, Bi S, et al (2019) A deep neural network for anomaly detection and forecasting for multivariate time series in smart city. In: IEEE Int. Conf. Cyber Technol. Autom. Control Intell. Syst. (CYBER'19), pp 615–620, https://doi.org/10.1109/CYBER46603.2019.9066655

[Cat88] He J, Dong Z, Huang Y (2024b) Multivariate time series anomaly detection with adaptive transformer-CNN architecture fusing adversarial training. In: IEEE Data Driven Control Learn. Syst. Conf. (DDCLS'24), pp 1387–1392, https://doi.org/10.1109/DDCLS61622.2024.10606841

[Cat89] He Q, Zheng YJ, Zhang C, et al (2020) MTAD-TF: Multivariate time series anomaly detection using the combination of temporal pattern and feature pattern. Complexity 2020. https://doi.org/10.1155/2020/8846608

[Cat90] He Q, Wang G, Huo L, et al (2023a) ACAM-AD: Autocorrelation and attention mechanism-based anomaly detection in multivariate time series. J Intell Fuzzy Syst 44(6):9039–9051. https://doi.org/10.3233/JIFS-224416

[Cat91] He Q, Wang G, Wang H, et al (2023b) Multivariate time-series anomaly detection via temporal convolutional and graph attention networks. J Intell Fuzzy Syst 44(4):5953–5962. https://doi.org/10.3233/jifs-222554

[Cat92] He S, Huang H, Yoo S, et al (2021) Flight data anomaly detection and diagnosis with variable association change. In: Proc. ACM/SIGAPP Symp. Appl. Comput (SAC'21), p 346–354, https://doi.org/10.1145/3412841.3441916

[Cat93] He S, Guo M, Yang B, et al (2023c) Fine-grained multivariate time series anomaly detection in iot. Comput Mater Continua 75(3):5027–5047. https://doi.org/10.32604/cmc.2023.038551

[Cat94] He S, Du M, Jiang X, et al (2024c) VAEAT: Variational autoeencoder with adversarial training for multivariate time series anomaly detection. Inf Sci 676. https://doi.org/10.1016/j.ins.2024.120852

[Cat95] He S, Li G, Guo Q, et al (2024d) Multi-graph structure learning-based multivariate time series anomaly detection with extended prior knowledge. In: IEEE Int. Conf. Comput. Support. Coop. Work Des. (CSCWD'24), pp 109–114, https://doi.org/10.1109/CSCWD61410.2024.10580531

[Cat96] He S, Li G, Xie K, et al (2024e) Fusion graph structure learning-based multivariate time series anomaly detection with structured prior knowledge. IEEE Trans Inf Forensics Secur 19:8760–8772. https://doi.org/10.1109/TIFS.2024.3459631

[Cat97] He S, Li G, Yi T, et al (2024f) Graph structure learning-based multivariate time series anomaly detection in internet of things for human-centric consumer applications. IEEE Trans Consum Electron 70(3):5419–5431. https://doi.org/10.1109/TCE.2024.3409391

[Cat98] He Y, Zhao J (2019) Temporal convolutional networks for anomaly detection in time series. J Phys: Conf Ser 1213(4). https://doi.org/10.1088/1742-6596/1213/4/042050

[Cat99] He Z, Chen P, Li X, et al (2023d) A spatiotemporal deep learning approach for unsupervised anomaly detection in cloud systems. IEEE Trans Neural Netw Learn Syst 34(4):1705–1719. https://doi.org/10.1109/tnnls.2020.3027736

[Cat100] Hojjati H, Sadeghi M, Armanfard N (2023) Multivariate time-series anomaly detection with temporal self-supervision and graphs: Application to vehicle failure prediction. In: Mach. Learn. Knowl. Discov. Databases (ECML PKDD'23), p 242–259, https://doi.org/10.1007/978-3-031-43430-3_15

[Cat101] Hsieh RJ, Chou J, Ho CH (2019) Unsupervised online anomaly detection on multivariate sensing time series data for smart manufacturing. In: IEEE Int. Conf. Serv.-Oriented Comput. Appl. (SOCA'19), pp 90–97, https://doi.org/10.1109/SOCA.2019.00021

[Cat102] Hsu T, Tseng YC, Chen JJ (2022) Graph attention transformer for unsupervised multivariate time series anomaly detection. In: Machine Learn. Earth Observ. Workshop (MACLEAN'22@PKDD/ECML), URL https://ceur-ws.org/Vol-3345/

[Cat103] Hu R, Yuan X, Qiao Y, et al (2024) Unsupervised anomaly detection for multivariate time series using diffusion model. In: IEEE Int. Conf. Acoust. Speech Signal Process. (ICASSP'24), pp 9606–9610, https://doi.org/10.1109/ICASSP48485.2024.10447083

[Cat104] Hua X, Zhu L, Zhang S, et al (2022) GenAD: General unsupervised anomaly detection using multivariate time series for large-scale wireless base stations. Electron Lett 59(1). https://doi.org/10.1049/ell2.12683, URL http://dx.doi.org/10.1049/ell2.12683

[Cat105] Huang J, Liu C, Yang Y, et al (2023) A GAN-based power quality anomaly detection method for imbalanced multivariate time series. In: IEEE Int. Conf. Comput. Commun. Eng. Technol. (CCET'23), pp 187–191, https://doi.org/10.1109/CCET59170.2023.10335146

[Cat106] Huang J, Xu D, Yang T (2024a) Fed-SMAE: Federated-learning based time series anomaly detection with shared memory augmented autoencoder. In: IEEE Int. Conf. Ind. Cyber Phys. Syst. (ICPS'24), pp 1–6, https://doi.org/10.1109/ICPS59941.2024.10640001

[Cat107] Huang X, Chen N, Deng Z, et al (2024b) Multivariate time series anomaly detection via dynamic graph attention network and informer. Appl Intell 54(17–18):7636–7658. https://doi.org/10.1007/s10489-024-05575-y

[Cat108] Huang X, Wu Y, Ye Y (2024c) Spatio-temporal correlation aware graph attention network for anomaly detection in multivariate time series. In: IEEE Int. Conf. Intell. Comput. Signal Process. (ICSP'24), pp 698–704, https://doi.org/10.1109/ICSP62122.2024.10743431

[Cat109] Huang Y, Liu W, Li S, et al (2024d) MGAD: Mutual information and graph embedding based anomaly detection in multivariate time series. Electronics 13(7). https://doi.org/10.3390/electronics13071326

[Cat110] Huo W, Wang Y, Ye L (2024) A mixed augmentations method for multivariate time series contrastive learning. In: IEEE Int. Symp. Parallel Distrib. Process. Appl. (ISPA'24), pp 1782–1789, https://doi.org/10.1109/ISPA63168.2024.00243

[Cat111] Ishaq MY, Yong Z, Xue S, et al (2024) Deep block transformer for anomaly detection. In: IEEE Int. Conf. Comput. Commun. Artif. Intell. (CCAI'24), pp 481–486, https://doi.org/10.1109/CCAI61966.2024.10603098

[Cat112] Jabłoński G (2020) VGG based unsupervised anomaly detection in multivariate time series. In: Adv. Contemp. Control, p 1287–1296, https://doi.org/10.1007/978-3-030-50936-1_107

[Cat113] Jang GB, Cho SB (2023) Multi-instance attention network for anomaly detection from multivariate time series. Cybern Syst 55(6):1417–1440. https://doi.org/

10.1080/01969722.2023.2240651

[Cat114] Ji Z, Wang Y, Yan K, et al (2022) A space-embedding strategy for anomaly detection in multivariate time series. Expert Syst Appl 206. https://doi.org/https://doi.org/10.1016/j.eswa.2022.117892

[Cat115] Jiang K, Liu H, Ruan H, et al (2023) ALAE: self-attention reconstruction network for multivariate time series anomaly identification. Soft Comput 27(15):10509–10519. https://doi.org/10.1007/s00500-023-08467-4

[Cat116] Jie X, Zhou X, Su C, et al (2024) Disentangled anomaly detection for multivariate time series. In: Proc. ACM World Wide Web Conf. (WWW'24), p 931–934, https://doi.org/10.1145/3589335.3651492

[Cat117] Jo H, Lee SW (2024) Edge conditional node update graph neural network for multivariate time series anomaly detection. Inf Sci 679. https://doi.org/10.1016/j.ins.2024.121062

[Cat118] Kakar JK, Hussain S, Kim SC, et al (2024) TimeTector: A twin-branch approach for unsupervised anomaly detection in livestock sensor noisy data (tt-tbad). Sensors 24(8). https://doi.org/10.3390/s24082453

[Cat119] Kang H, Kang P (2024) Transformer-based multivariate time series anomaly detection using inter-variable attention mechanism. Knowl-Based Syst 290. https://doi.org/10.1016/j.knosys.2024.111507

[Cat120] Kang J, Kim M, Park J, et al (2024a) Time-series to image-transformed adversarial autoencoder for anomaly detection. IEEE Access 12:119671–119684. https://doi.org/10.1109/access.2024.3450709

[Cat121] Kang J, Wan G, Lu J, et al (2024b) ISTAD: Scaled transformer with interactive learning for multivariate time series anomaly detection. In: IEEE Int. Conf. Pattern Recognit. Artif. Intell. (PRAI'24), pp 1030–1036, https://doi.org/10.1109/PRAI62207.2024.10827712

[Cat122] Kang JM, Kim MH (2023) Multivariate time series anomaly detection based on reconstructed differences using graph attention networks. In: Curr. Trends Web Eng. (ICWE'22), p 58–69, https://doi.org/10.1007/978-3-031-25380-5_5

[Cat123] Kang M, Lee B (2023) TiCTok: Time-series anomaly detection with contrastive tokenization. IEEE Access 11:81011–81020. https://doi.org/10.1109/access.2023.3301140

[Cat124] Kang Z, Mukhopadhyay A, Gokhale A, et al (2022) Traffic anomaly detection via conditional normalizing flow. In: IEEE Int. Conf. Intell. Transp. Syst. (ITSC'22), pp 2563–2570, https://doi.org/10.1109/ITSC55140.2022.9922061

[Cat125] Karadayı Y, Aydin MN, Öğrenci AS (2020) A hybrid deep learning framework for unsupervised anomaly detection in multivariate spatio-temporal data. Appl Sci 10(15). https://doi.org/10.3390/app10155191

[Cat126] Ketonen V, Blech JO (2021) Anomaly detection for injection molding using probabilistic deep learning. In: IEEE Int. Conf. Ind. Cyber Phys. Syst. (ICPS'21), pp 70–77, https://doi.org/10.1109/ICPS49255.2021.9468190

[Cat127] Kieu T, Yang B, Guo C, et al (2019) Outlier detection for time series with recurrent autoencoder ensembles. In: Proc. Int. Jt. Conf. Artif. Intell. (IJCAI'19), pp 2725–2732, https://doi.org/10.24963/ijcai.2019/378

[Cat128] Kim B, Kang JW, Kim CS, et al (2024a) Hybrid transformer for anomaly detection on railway hvac systems through feature ensemble of spatial–temporal with multi-channel gadf images. J Electr Eng Technol 19(4):2803–2815. https://doi.org/10.1007/s42835-024-01844-5

[Cat129] Kim H, Kim H (2023) Contextual anomaly detection for multivariate time series data. Qual Eng 35(4):686–695. https://doi.org/10.1080/08982112.2023.2179404

[Cat130] Kim H, Kim S, Min S, et al (2024b) Contrastive time-series anomaly detection. IEEE Trans Knowl Data Eng 36(10):5053–5065. https://doi.org/10.1109/tkde.2023.3335317

[Cat131] Kim M, Park S (2024) Unsupervised multi-head attention autoencoder for multivariate time-series anomaly detection. In: IEEE Int. Conf. Big Data Smart Comput. (BigComp'24), pp 1–7, https://doi.org/10.1109/BigComp60711.2024.00011

[Cat132] Kim M, Ou E, Loh PL, et al (2020) RNN-based online anomaly detection in nuclear reactors for highly imbalanced datasets with uncertainty. Nucl Eng Des 364. https://doi.org/https://doi.org/10.1016/j.nucengdes.2020.110699

[Cat133] Kong L, Yu J, Tang D, et al (2023) Multivariate time series anomaly detection with generative adversarial networks based on active distortion transformer. IEEE Sens J 23(9):9658–9668. https://doi.org/10.1109/JSEN.2023.3260563

[Cat134] Kou F, Yu L, Yue K, et al (2024) Anomaly detection for multivariate time series with multi-scale feature interactions. In: Database Syst. Adv. Appl. (DASFAA'24), p 459–475, https://doi.org/10.1007/978-981-97-5569-1_30

[Cat135] Kumari J, Mathew J, Mondal A (2024) MAD-MEL: Combining entity and metric learning for anomaly detection in multivariate time series. IEEE Sens J 24(3):3144–3156. https://doi.org/10.1109/JSEN.2023.3339335

[Cat136] Kuo CW, Ying JJC (2023) An unsupervised deep learning framework for anomaly detection. In: Intell. Inf. Database Syst. (ACIIDS'23), p 284–295, https://doi.org/10.1007/978-981-99-5834-4_23

[Cat137] Labaien J, Idé T, Chen PY, et al (2023) Diagnostic spatio-temporal transformer with faithful encoding. Knowl-Based Syst 274. https://doi.org/10.1016/j.knosys.2023.110639

[Cat138] Lai T, Ho TKK, Armanfard N (2024) Open-set multivariate time-series anomaly detection. In: Eur. Conf. Artif. Intell. (ECAI'24), pp 2003 – 2010, https://doi.org/10.3233/faia240716

[Cat139] Lanko V, Makarov I (2024) Graph-attention diffusion for enhanced multivariate time-series anomaly detection. IEEE Open J Ind Electron Soc 5:1353–1364. https://doi.org/10.1109/OJIES.2024.3501014

[Cat140] Le T, Vu HC, Ponchet-Durupt A, et al (2024) Unsupervised detecting anomalies in multivariate time series by robust convolutional LSTM encoder–decoder (RCLED). Neurocomputing 592. https://doi.org/10.1016/j.neucom.2024.127791

[Cat141] Lee B, Kim S, Maqsood M, et al (2024) Advancing autoencoder architectures for enhanced anomaly detection in multivariate industrial time series. Comput Mater Contin 81(1):1275–1300. https://doi.org/https://doi.org/10.32604/cmc.2024.054826

[Cat142] Lee J, Lee S (2024) Separable contextual graph neural networks to identify tailgating-oriented traffic congestion. Expert Syst Appl 254. https://doi.org/10.1016/j.eswa.2024.124354

[Cat143] Lee J, Park B, Chae DK (2023) DuoGAT: Dual time-oriented graph attention networks for accurate, efficient and explainable anomaly detection on time-series. In: Proc. ACM Int. Conf. Inf. Knowl. Manag. (CIKM'23), p 1188–1197, https://doi.org/10.1145/3583780.3614857

[Cat144] Lee S, Woo SS (2024) Saliency-aware time series anomaly detection for space applications. In: Adv. Knowl. Discov. Data Min. (PAKDD'24), p 327–339, https://doi.org/10.1007/978-981-97-2242-6_26

[Cat145] Li D, Chen D, Jin B, et al (2019) MAD-GAN: Multivariate anomaly detection for time series data with generative adversarial networks. In: Artif. Neural Netw. Mach. Learn. (ICANN'19): Text and Time Series, pp 703–716, https://doi.org/10.1007/978-3-030-30490-4_56

[Cat146] Li G, Yang Z, Wan H, et al (2022a) Anomaly-ptg: A time series data-anomaly-detection transformer framework in multiple scenarios. Electronics 11(23). https://doi.org/10.3390/electronics11233955

[Cat147] Li H, Xu H, Peng W, et al (2023a) Multi-scale sampling based MLP networks for anomaly detection in multivariate time series. In: IEEE Int. Conf. Parallel Distrib. Syst. (ICPADS'23), pp 1421–1428, https://doi.org/10.1109/icpads60453.2023.00202

[Cat148] Li H, Kong X, Shen G, et al (2024a) Point-correlate adversarial transformer for unsupervised multivariate time series anomaly detection. In: IEEE Int. Conf. Comput. Support. Coop. Work Des. (CSCWD'24), pp 297–302, https://doi.org/10.1109/CSCWD61410.2024.10580188

[Cat149] Li J, Liu C, Ding J (2024b) Graph Transformer: Anomaly prediction and interpretation in multivariate time series. In: IEEE Int. Jt. Conf. Neural Netw. (IJCNN'24), pp 1–8, https://doi.org/10.1109/IJCNN60899.2024.10650606

[Cat150] Li L, Yan J, Wang H, et al (2021a) Anomaly detection of time series with smoothness-inducing sequential variational auto-encoder. IEEE Trans Neural Netw Learn Syst 32(3):1177–1191. https://doi.org/10.1109/TNNLS.2020.2980749

[Cat151] Li M, Li Z, Yang Z, et al (2024c) Sa2e-ad: A stacked attention autoencoder for anomaly detection in multivariate time series. ACM Trans Knowl Discov Data 18(7). https://doi.org/10.1145/3653677

[Cat152] Li Q, Yan T, Yuan H, et al (2022b) Self-attention-based multivariate anomaly detection for cps time series data with adversarial autoencoders. In: IEEE Chin. Control Conf. (CCC'22), pp 4251–4256, https://doi.org/10.23919/CCC55666.2022.9902551

[Cat153] Li W, Hu W, Chen T, et al (2022c) StackVAE-G: An efficient and interpretable model for time series anomaly detection. AI Open 3:101–110. https://doi.org/10.1016/j.aiopen.2022.07.001

[Cat154] Li X, Wen P, Chen P, et al (2024d) An effective parallel convolutional anomaly multi-classification model for fault diagnosis in microservice system. Software Qual J 32(3):921–938. https://doi.org/10.1007/s11219-024-09672-6

[Cat155] Li Y, Chen W, Chen B, et al (2023b) Prototype-oriented unsupervised anomaly detection for multivariate time series. In: Proc. Int. Conf. Mach. Learn. (ICML'23), pp 19407–19424, URL https://openreview.net/forum?id=3vO4lS6PuF

[Cat156] Li Y, Peng X, Zhang J, et al (2023c) DCT-GAN: Dilated convolutional transformer-based gan for time series anomaly detection. IEEE Trans Knowl Data Eng 35(4):3632–3644. https://doi.org/10.1109/TKDE.2021.3130234

[Cat157] Li Y, Zhang N, Zhang C (2024e) A multivariate time series anomaly detection model based on wavelet decomposition for spatiotemporal feature fusion. In: IEEE Int. Symp. Comput. Eng. Intell. Commun. (ISCEIC'24), pp 197–200, https://doi.org/10.1109/ISCEIC63613.2024.10810213

[Cat158] Li YF, Hu ZA, Gao JW, et al (2024f) Efficient anomaly detection method for offshore wind turbines. J Electron Sci Technol 22(4). https://doi.org/10.1016/j.jnlest.2024.100285

[Cat159] Li Z, Zhao Y, Han J, et al (2021b) Multivariate time series anomaly detection and interpretation using hierarchical inter-metric and temporal embedding. In: Proc. ACM SIGKDD Int. Conf. Knowl. Discov. Data Min. (KDD'21), pp 3220–3230, https://doi.org/10.1145/3447548.3467075

[Cat160] Li Z, Zhao Y, Geng Y, et al (2022d) Situation-aware multivariate time series anomaly detection through active learning and contrast VAE-based models in large distributed systems. IEEE J Sel Areas Commun 40(9):2746–2765. https://doi.org/10.1109/JSAC.2022.3191341

[Cat161] Li Z, Xu D, Li Y, et al (2023d) OSVAE-GAN: Orthogonal self-attention variational autoencoder generative adversarial networks for time series anomaly detection. In: IEEE Symp. Ser. Comput. Intell. (SSCI'23), pp 19–24, https://doi.org/10.1109/SSCI52147.2023.10371977

[Cat162] Li Z, Zhang H, Zheng W (2024g) STformer: Spatio-temporal transformer for multivariate time series anomaly detection. In: Artif. Neural Netw. Mach. Learn. (ICANN'24), p 297–311, https://doi.org/10.1007/978-3-031-72347-6_20, URL http://dx.doi.org/10.1007/978-3-031-72347-6_20

[Cat163] Lian Y, Geng Y, Tian T (2023) Anomaly detection method for multivariate time series data of oil and gas stations based on digital twin and MTAD-GAN. Appl Sci 13(3). https://doi.org/10.3390/app13031891

[Cat164] Liang H, Song L, Wang J, et al (2021) Robust unsupervised anomaly detection via multi-time scale dcgans with forgetting mechanism for industrial multivariate time series. Neurocomputing 423:444–462. https://doi.org/10.1016/j.neucom.2020.10.084

[Cat165] Liang H, Song L, Du J, et al (2022) Consistent anomaly detection and localization of multivariate time series via cross-correlation graph-based encoder–decoder gan. IEEE Trans Instrum Meas 71:1–10. https://doi.org/10.1109/TIM.2021.3139696

[Cat166] Liang L, Qiu X, Zhang Y, et al (2024a) Stationary multi-scale hierarchical dilated graph convolution for multivariate time series anomaly detection. In: Big Data Secur. (ICBDS'23), p 52–66, https://doi.org/10.1007/978-981-97-4390-2_5

[Cat167] Liang S, Pi D, Zhang X (2024b) Anomaly detection model for large-scale industrial systems using transfer entropy and graph attention network. Meas Sci Technol 35(9). https://doi.org/10.1088/1361-6501/ad545e

[Cat168] Liang Z, Zhang J, Liang C, et al (2023) A shapelet-based framework for unsupervised multivariate time series representation learning. Proc VLDB Endow 17(3):386–399. https://doi.org/10.14778/3632093.3632103

[Cat169] Liao J, Li J, Chen Y, et al (2024) DPDGAD: A dual-process dynamic graph-based anomaly detection for multivariate time series analysis in cyber-physical systems. Adv Eng Inform 61. https://doi.org/10.1016/j.aei.2024.102547

[Cat170] Lin C, Du B, Sun L, et al (2024a) Hierarchical context representation and self-adaptive thresholding for multivariate anomaly detection. IEEE Trans Knowl Data Eng 36(7):3139–3150. https://doi.org/10.1109/TKDE.2024.3360640

[Cat171] Lin S, Faust L, D'Mello S, et al (2020) MBead: Semi-supervised multil-abel behaviour anomaly detection on multivariate temporal sensory data. In: IEEE Int. Conf. Big Data (Big Data'20), pp 1089–1096, https://doi.org/10.1109/bigdata50022.2020.9378327

[Cat172] Lin W, Wang S, Wu W, et al (2024b) HybridAD: A hybrid model-driven anomaly detection approach for multivariate time series. IEEE Trans Emerg Top Comput Intell 8(1):866–878. https://doi.org/10.1109/TETCI.2023.3290027

[Cat173] Lin Y, Chiang YY (2022) A semi-supervised learning approach for abnormal event prediction on large network operation time-series data. In: IEEE Int. Conf. Big Data (Big Data'22), pp 1024–1033, https://doi.org/10.1109/BigData55660.2022.10020157

[Cat174] Liu H, Luo W, Han L, et al (2024a) Anomaly detection via graph attention networks-augmented mask autoregressive flow for multivariate time series. IEEE Internet Things J 11(11):19368–19379. https://doi.org/10.1109/JIOT.2024.3362398

[Cat175] Liu L, Tian L, Kang Z, et al (2023a) Spacecraft anomaly detection with attention temporal convolution networks. Neural Comput Appl 35(13):9753–9761. https://doi.org/10.1007/s00521-023-08213-9

[Cat176] Liu S, Zhou N, Bai Z, et al (2023b) The study on multivariate time series anomaly detection via convolutional variational autoencoder. In: IEEE Int. Conf. Autom. Electron. Electr. Eng. (AUTEEE'23), pp 605–610, https://doi.org/10.1109/AUTEEE60196.2023.10407274

[Cat177] Liu W, Sun D, Yang H, et al (2023c) IAD-Net: Multivariate kpis interpretable anomaly detection with dual gated residual fusion networks. In: IEEE Int. Conf. Trust Secur. Privacy Comput. Commun. (TrustCom'23), pp 686–693, https://doi.org/10.1109/TrustCom60117.2023.00103

[Cat178] Liu W, Yan L, Ma N, et al (2024b) Unsupervised deep anomaly detection for industrial multivariate time series data. Appl Sci 14(2). https://doi.org/10.3390/app14020774

[Cat179] Liu W, Zhang W, Jiang Y, et al (2024c) Learning triple-view representation discrepancy for multivariate time series anomaly detection with multi-scale patching. In: IEEE Int. Conf. Parallel Distrib. Syst. (ICPADS'24), pp 560–567, https://doi.org/10.1109/icpads63350.2024.00079

[Cat180] Liu Y, Han Y, An W (2022) AttVAE: A novel anomaly detection framework for multivariate time series. In: Sci. Cyber Secur.(SciSec'22), p 407–420, https://doi.

org/10.1007/978-3-031-17551-0_27

[Cat181] Liu Z, Huang X, Zhang J, et al (2024d) Multivariate time-series anomaly detection based on enhancing graph attention networks with topological analysis. In: Proc. ACM Int. Conf. Inf. Knowl. Manag. (CIKM '24), p 1555–1564, https://doi.org/10.1145/3627673.3679614

[Cat182] Long J, Luo C, Chen R, et al (2024) A cross-layered cluster embedding learning network with regularization for multivariate time series anomaly detection. J Supercomput 80(8):10444–10468. https://doi.org/10.1007/s11227-023-05833-9

[Cat183] Lu S, Dong Z, Cai D, et al (2023) MIM-GAN-based anomaly detection for multivariate time series data. In: IEEE Veh. Technol. Conf. (VTC'23-Fall), pp 1–7, https://doi.org/10.1109/VTC2023-Fall60731.2023.10333517

[Cat184] Luo Y, Chen N, Huang Z, et al (2024) Pyramid transformer for multivariate time series anomaly detection in iout. In: IEEE Int. Conf. Smart Internet Things (SmartIoT'24), pp 533–539, https://doi.org/10.1109/SmartIoT62235.2024.00088

[Cat185] Lv J, Wang Y, Chen S (2023) Adaptive multivariate time-series anomaly detection. Inf Process Manag 60(4). https://doi.org/10.1016/j.ipm.2023.103383

[Cat186] Ma J, Wang H (2024) Anomaly detection in sensor data via encoding time series into images. J King Saud Univ Comput Inf Sci 36(10). https://doi.org/10.1016/j.jksuci.2024.102232

[Cat187] Ma M, Han L, Zhou C (2023a) BTAD: A binary transformer deep neural network model for anomaly detection in multivariate time series data. Adv Eng Inform 56. https://doi.org/10.1016/j.aei.2023.101949

[Cat188] Ma M, Hua X, Zhang Y, et al (2024a) Spatiotemporal polynomial graph neural network for anomaly detection of complex systems. Measurement 235. https://doi.org/10.1016/j.measurement.2024.115035

[Cat189] Ma S, Guan S, He Z, et al (2023b) TPAD: Temporal-pattern-based neural network model for anomaly detection in multivariate time series. IEEE Sens J 23(24):30668–30682. https://doi.org/10.1109/JSEN.2023.3327138

[Cat190] Ma S, Nie J, Guan S, et al (2024b) MPFormer: Multipatch transformer for multivariate time-series anomaly detection with contrastive learning. IEEE Internet of Things J 11(23):38221–38237. https://doi.org/10.1109/JIOT.2024.3443910

[Cat191] Ma Z, Xia H, Chen G (2024c) MultiCon-AD: Integrated contrastive learning for multivariate time series anomaly detection. In: IEEE Int. Semin. Artif. Intell. Netw. Inf. Technol. (AINIT'24), p 2333–2338, https://doi.org/10.1109/ainit61980.2024.10581787, URL http://dx.doi.org/10.1109/ainit61980.2024.10581787

[Cat192] Macas M, Wu C (2019) An unsupervised framework for anomaly detection in a water treatment system. In: IEEE Int. Conf. Mach. Learn. Appl. (ICMLA'19), pp 1298–1305, https://doi.org/10.1109/ICMLA.2019.00212

[Cat193] Maru C, Brandherm B, Kobayashi I (2022) Combining transformer with a discriminator for anomaly detection in multivariate time series. In: IEEE Jt. Int. Conf. Soft Comput. Intell. Syst. & Int. Symp. Adv. Intell. Syst. (SCIS&ISIS), pp 1–7, https://doi.org/10.1109/SCISISIS55246.2022.10002131

[Cat194] Matar M, Xia T, Huguenard K, et al (2023a) Anomaly detection in coastal wireless sensors via efficient deep sequential learning. IEEE Access 11:110260–110271. https://doi.org/10.1109/access.2023.3322370

[Cat195] Matar M, Xia T, Huguenard K, et al (2023b) Multi-head attention based Bi-LSTM for anomaly detection in multivariate time-series of wsn. In: IEEE Int. Conf. Artif. Intell. Circuits Syst. (AICAS'23), pp 1–5, https://doi.org/10.1109/AICAS57966.2023.10168670

[Cat196] Meng F, Yang Q, He Z, et al (2022) GUARD: Multigranularity-based unsupervised anomaly detection algorithm for multivariate time series. In: IEEE Int. Conf. Commun. Image Signal Process. (CCISP'22), pp 25–30, https://doi.org/10.1109/CCIS57298.2022.10016429

[Cat197] Meng Z, Zhu X, Pan F, et al (2023) DA-MTAD: Capturing intra- and inter-metric dependencies for multivariate time series anomaly detection. In: IEEE Int. Conf. Syst. Man Cybern. (SMC'23), pp 2660–2666, https://doi.org/10.1109/SMC53992.2023.10394599

[Cat198] Miao J, Tao H, Xie H, et al (2024a) Reconstruction-based anomaly detection for multivariate time series using contrastive generative adversarial networks. Inf Process Manag 61(1). https://doi.org/10.1016/j.ipm.2023.103569

[Cat199] Miao Q, Xu C, Zhan J, et al (2023) An unsupervised short- and long-term mask representation for multivariate time series anomaly detection. In: Neural Inf. Process. (ICONIP'22), p 504–516, https://doi.org/10.1007/978-981-99-1645-0_42

[Cat200] Miao Q, Wang D, Xu C, et al (2024b) An unsupervised long- and short-term sparse graph neural network for multisensor anomaly detection. IEEE Sens J 24(14):23088–23097. https://doi.org/10.1109/JSEN.2024.3383665

[Cat201] Miele ES, Bonacina F, Corsini A (2022) Deep anomaly detection in horizontal axis wind turbines using graph convolutional autoencoders for multivariate time series. Energy and AI 8. https://doi.org/https://doi.org/10.1016/j.egyai.2022.100145

[Cat202] Na D, Kwon J (2024) MRDiff: Time series anomaly detection using multi-level reconstruction diffusion. In: IEEE Int. Conf. Data Min. Workshops (ICDMW'24), pp 688–695, https://doi.org/10.1109/ICDMW65004.2024.00095

[Cat203] Naito S, Taguchi Y, Nakata K, et al (2021) Anomaly detection for multivariate time series on large-scale fluid handling plant using two-stage autoencoder. In: IEEE Int. Conf. Data Min. Workshops (ICDMW'21), pp 542–551, https://doi.org/10.1109/ICDMW53433.2021.00072

[Cat204] Nguyen H, Tran K, Thomassey S, et al (2021) Forecasting and anomaly detection approaches using LSTM and LSTM autoencoder techniques with the applications in supply chain management. Int J Inf Manag 57. https://doi.org/10.1016/j.ijinfomgt.2020.102282

[Cat205] Ning Z, Jiang Z, Miao H, et al (2023) MST-GNN: A multi-scale temporal-enhanced graph neural network for anomaly detection in multivariate time series. In: Web and Big Data (APWeb-WAIM'22), p 382–390, https://doi.org/10.1007/978-3-031-25158-0_29

[Cat206] Niu M, Zhao Y, Haddadi H (2023) Effective abnormal activity detection on multivariate time series healthcare data. In: Proc. ACM Int. Conf. Mob. Comput. Netw. (MobiCom'23), https://doi.org/10.1145/3570361.3615741

[Cat207] Niu Z, Yu K, Wu X (2020) LSTM-based VAE-GAN for time-series anomaly detection. Sensors 20(13). https://doi.org/10.3390/s20133738

[Cat208] Nivarthi CP, Sick B (2023) Towards few-shot time series anomaly detection with temporal attention and dynamic thresholding. In: IEEE Int. Conf. Mach. Learn. Appl. (ICMLA'23), pp 1444–1450, https://doi.org/10.1109/ICMLA58977.2023.00218

[Cat209] Nizam H, Zafar S, Lv Z, et al (2022) Real-time deep anomaly detection framework for multivariate time-series data in industrial iot. IEEE Sens J 22(23):22836–22849. https://doi.org/10.1109/JSEN.2022.3211874

[Cat210] Oh S, Anh LH, Vu DT, et al (2024) Patch-wise-based self-supervised learning for anomaly detection on multivariate time series data. Mathematics 12(24). https://doi.org/10.3390/math12243969

[Cat211] Orabi M, Tran KP, Egger P, et al (2024) Anomaly detection in smart manufacturing: An adaptive adversarial transformer-based model. J Manuf Syst 77:591–611. https://doi.org/10.1016/j.jmsy.2024.09.021

[Cat212] Oswal S, Shinde S, M V (2024) Unlocking long-term temporal patterns: TCAE for anomaly detection in multivariate time series data. Int J Eng Trends Technol 72(9):283–296. https://doi.org/10.14445/22315381/ijett-v72i9p123

[Cat213] Pan J, Ji W, Zhong B, et al (2023) DUMA: Dual mask for multivariate time series anomaly detection. IEEE Sens J 23(3):2433–2442. https://doi.org/10.1109/JSEN.2022.3225338

[Cat214] Pang H, Wei S, Li Y, et al (2024) Asymptotic consistent graph structure learning for multivariate time-series anomaly detection. IEEE Trans Instrum Meas 73:1–10. https://doi.org/10.1109/TIM.2024.3369159

[Cat215] Peng X, Lin Y, Cao Q, et al (2022) Traffic anomaly detection in intelligent transport applications with time series data using informer. In: Int. Conf. Intell. Transp. Syst. (ITSC'22), pp 3309–3314, https://doi.org/10.1109/ITSC55140.2022.9922142

[Cat216] Pham TA, Lee JH, Park CS (2022) MST-VAE: Multi-scale temporal variational autoencoder for anomaly detection in multivariate time series. Appl Sci 12(19). https://doi.org/10.3390/app121910078

[Cat217] Pintilie I, Manolache A, Brad F (2023) Time series anomaly detection using diffusion-based models. In: IEEE Int. Conf. Data Min. Workshops (ICDMW'23), pp 570–578, https://doi.org/10.1109/ICDMW60847.2023.00080

[Cat218] Pydi DP, Advaith S (2023) Attention boosted autoencoder for building energy anomaly detection. Energy and AI 14. https://doi.org/10.1016/j.egyai.2023.100292

[Cat219] Qi P, Li D, Ng SK (2022) MAD-SGCN: Multivariate anomaly detection with self-learning graph convolutional networks. In: IEEE Int. Conf. Data Eng. (ICDE'22), pp 1232–1244, https://doi.org/10.1109/ICDE53745.2022.00097

[Cat220] Qi S, Chen J, Chen P, et al (2023a) An effective dynamic cost-sensitive weighting based anomaly multi-classification model for imbalanced multivariate time series. In: Web Inf. Syst. Eng. (WISE'23), pp 781–790, https://doi.org/10.1007/978-981-99-7254-8_60

[Cat221] Qi S, Chen J, Chen P, et al (2023b) An efficient GAN-based predictive framework for multivariate time series anomaly prediction in cloud data centers. J Supercomput 80(1):1268–1293. https://doi.org/10.1007/s11227-023-05534-3

[Cat222] Qi Z, Xie H, Shang M (2023c) A predictive coding approach to multivariate time series anomaly detection. In: Database Syst. Adv. Appl. (DASFAA'23), p 188–204, https://doi.org/10.1007/978-3-031-30637-2_13

[Cat223] Qin S, Zhu J, Wang D, et al (2022) Decomposed transformer with frequency attention for multivariate time series anomaly detection. In: IEEE Int. Conf. Big Data (Big Data'22), pp 1090–1098, https://doi.org/10.1109/BigData55660.2022.10021063

[Cat224] Qin S, Chen L, Luo Y, et al (2023a) Multiview graph contrastive learning for multivariate time-series anomaly detection in iot. IEEE Internet Things J 10(24):22401–22414. https://doi.org/10.1109/JIOT.2023.3303946

[Cat225] Qin S, Luo Y, Tao G (2023b) Memory-augmented U-Transformer for multivariate time series anomaly detection. In: IEEE Int. Conf. Acoust. Speech Signal Process.

(ICASSP'23), pp 1–5, https://doi.org/10.1109/ICASSP49357.2023.10096179

[Cat226] Sabbaqi M, Taormina R, Hanjalic A, et al (2022) Graph-time convolutional autoencoders. In: Proc. Learn. Graphs Conf. (LoG'22), pp 1–20, URL https://openreview.net/forum?id=2HqKwHaBwv

[Cat227] Saravana MK, Roopa MS, Arunalatha JS, et al (2024) Graph laplacian eigenvalues empowered VAEs: A novel approach to adaptive latent dimension choice. IEEE Access 12:135265–135282. https://doi.org/10.1109/ACCESS.2024.3460971

[Cat228] Schoch F, Graf P, Schmieg T, et al (2024) Deep anomaly detection with extended transformer-based model on tennessee eastman process dataset. In: IEEE Int. Conf. Comput. Sci. Inf. Technol. (CSIT'24), pp 1–4, https://doi.org/10.1109/CSIT65290.2024.10982582

[Cat229] Senane Z, Cao L, Buchner VL, et al (2024) Self-supervised learning of time series representation via diffusion process and imputation-interpolation-forecasting mask. In: Proc. ACM SIGKDD Int. Conf. Knowl. Discov. Data Min. (KDD'24), p 2560–2571, https://doi.org/10.1145/3637528.3671673

[Cat230] Seong C, Lim D, Jang J, et al (2023) Multivariate time series anomaly detection with deep learning models leveraging inter-variable relationships. In: IEEE Silicon Valley Cybersecur. Conf. (SVCC'23), pp 1–8, https://doi.org/10.1109/SVCC56964.2023.10165468

[Cat231] Shan J, Cai D, Fang F, et al (2024) Unsupervised multivariate time series data anomaly detection in industrial iot: A confidence adversarial autoencoder network. IEEE Open J Commun Soc 5:7752–7766. https://doi.org/10.1109/OJCOMS.2024.3511951

[Cat232] Shang X, Zhang J, Jiang X, et al (2024) Anomaly detection for multivariate time series based on contrastive learning and autoformer. In: IEEE Int. Conf. Comput. Support. Coop. Work Des. (CSCWD'24), pp 2614–2619, https://doi.org/10.1109/CSCWD61410.2024.10580672

[Cat233] Shen L, Li Z, Kwok JT (2020) Timeseries anomaly detection using temporal hierarchical one-class network. In: Adv. Neural Inf. Process. Syst. (NeurIPS'20), pp 13016–13026, URL https://proceedings.neurips.cc/paper/2020/hash/97e401a02082021fd24957f852e0e475-Abstract.html

[Cat234] Shi Y, Wang B, Yu Y, et al (2023) Robust anomaly detection for multivariate time series through temporal GCNs and attention-based VAE. Knowl-Based Syst 275. https://doi.org/10.1016/j.knosys.2023.110725

[Cat235] Shu X, Bao T, Zhou Y, et al (2022) Unsupervised dam anomaly detection with spatial–temporal variational autoencoder. Struct Health Monit 22(1):39–55. https://doi.org/10.1177/14759217211073301

[Cat236] Si H, Pei C, Li Z, et al (2023) Beyond sharing: Conflict-aware multivariate time series anomaly detection. In: Proc. ACM Jt. Eur. Softw. Eng. Conf. & Symp. Found. Softw. Eng. (ESEC/FSE'23), p 1635–1645, https://doi.org/10.1145/3611643.3613896

[Cat237] Singh SK, Anisi MH, Clough S, et al (2023) CNN-BiLSTM based GAN for anamoly detection from multivariate time series data. In: IEEE Int. Conf. Digit. Signal Process. (DSP'23), pp 1–4, https://doi.org/10.1109/DSP58604.2023.10167937

[Cat238] Son J, Song S, Baek JG (2024) Patch-based time-series anomaly detection with cross-variable attention. In: IEEE Int. Conf. Artif. Intell. Inf. Commun. (ICAIIC'24), pp 638–643, https://doi.org/10.1109/ICAIIC60209.2024.10463377

[Cat239] Song J, Kim K, Oh J, et al (2023a) MEMTO: memory-guided transformer for multivariate time series anomaly detection. In: Adv. Neural Inf. Process. Syst. (NeurIPS'23), pp 57947–57963, URL https://papers.nips.cc/paper_files/paper/2023/hash/b4c898eb1fb556b8d871fbe9ead92256-Abstract-Conference.html

[Cat240] Song W, Li X, Chen P, et al (2024) A novel graph structure learning based semi-supervised framework for anomaly identification in fluctuating iot environment. CMES - Comput Model Eng Sci 140(3):3001–3016. https://doi.org/https://doi.org/10.32604/cmes.2024.048563

[Cat241] Song Y, Li D (2024) Application of a novel data-driven framework in anomaly detection of industrial data. IEEE Access 12:102798–102812. https://doi.org/10.1109/ACCESS.2024.3420878

[Cat242] Song Y, Xin R, Chen P, et al (2023b) Identifying performance anomalies in fluctuating cloud environments: A robust correlative-GNN-based explainable approach. Future Gener Comput Syst 145:77–86. https://doi.org/https://doi.org/10.1016/j.future.2023.03.020

[Cat243] Sowmya K, Ramesh K (2024) Enhancing anomaly detection in multivariate time series with stacked transformer encoders and adaptive positional embeddings. Arab J Sci Eng 50(15):12479–12494. https://doi.org/10.1007/s13369-024-09821-w

[Cat244] Stepashkina VP, Hushchyn MI (2024) Prediction of industrial cyber attacks using normalizing flows. Dokl Math 110(S1):S95–S102. https://doi.org/10.1134/s1064562424602269

[Cat245] Su Y, Zhao Y, Niu C, et al (2019) Robust anomaly detection for multivariate time series through stochastic recurrent neural network. In: Proc. ACM SIGKDD Int. Conf. Knowl. Discov. Data Min. (KDD'19), pp 2828–2837, https://doi.org/10.1145/3292500.3330672

[Cat246] Sui J, Yu J, Song Y, et al (2024) Anomaly detection for telemetry time series using a denoising diffusion probabilistic model. IEEE Sens J 24(10):16429–16439.

https://doi.org/10.1109/jsen.2024.3383416

[Cat247] Sun C, He Z, Lin H, et al (2023) Anomaly detection of power battery pack using gated recurrent units based variational autoencoder. Appl Soft Comput 132. https://doi.org/https://doi.org/10.1016/j.asoc.2022.109903

[Cat248] Sun H, Huang Y, Han L, et al (2024a) MTS-DVGAN: Anomaly detection in cyber-physical systems using a dual variational generative adversarial network. Comput Secur 139. https://doi.org/10.1016/j.cose.2023.103570

[Cat249] Sun J, Chen Z, Qian Y (2024b) A contrastive-representative-learning-based method for multivariate time series anomaly detection. In: IEEE Int. Conf. Image Process. Comput. Vis. Mach. Learn. (ICICML'24), pp 546–549, https://doi.org/10.1109/ICICML63543.2024.10958101

[Cat250] Sun Q, Li Y, Hu Z, et al (2024c) Spatial-temporal dependency based multivariate time series anomaly detection for industrial processes. In: Adv. Intell. Comput. Technol. Appl. (ICIC'24), p 212–223, https://doi.org/10.1007/978-981-97-5618-6_18

[Cat251] Sun Y, Guo Y, Liang M, et al (2024d) Multivariate time series anomaly detection based on pre-trained models with dual-attention mechanism. In: IEEE Int. Symp. Softw. Reliab. Eng. Workshops (ISSREW'24), pp 73–78, https://doi.org/10.1109/ISSREW63542.2024.00050

[Cat252] Sun Z, Peng Q, Mou X, et al (2022) Generic and scalable periodicity adaptation framework for time-series anomaly detection. Multimed Tools Appl 82(2):2731–2748. https://doi.org/10.1007/s11042-022-13304-1

[Cat253] Tan Y, Li G, Chen Y, et al (2022) Multivariate time-series anomaly detection in iot using attention-based gated recurrent unit. In: IEEE Int. Conf. Wirel. Commun. Signal Process. (WCSP'22), pp 604–609, https://doi.org/10.1109/WCSP55476.2022.10039138

[Cat254] Tang C, Xu L, Yang B, et al (2023) GRU-based interpretable multivariate time series anomaly detection in industrial control system. Comput Mater Contin 127. https://doi.org/10.1016/j.cose.2023.103094

[Cat255] Tang C, Qin Y, Liu Y, et al (2024a) An efficient method for detecting abnormal electricity behavior. Energies 17(11). https://doi.org/10.3390/en17112502

[Cat256] Tang J, Li D, Zheng Z (2024b) MAD-SGS: Multivariate anomaly detection with multi-scale self-learned graph structures. In: Bio-Inspir. Comput.: Theories and Applications (BIC-TA'23), pp 17–31

[Cat257] Tang L, Kou E, Zhang W, et al (2024c) IoT-FKGDL-SL: Anomaly detection framework integrating knowledge distillation and a swarm learning for 5g iot.

IEEE Internet of Things J 11(23):38601–38614. https://doi.org/10.1109/JIOT.2024.3448429

[Cat258] Tao H, Miao J, Zhao L, et al (2023) HAN-CAD: hierarchical attention network for context anomaly detection in multivariate time series. World Wide Web 26(5):2785–2800. https://doi.org/10.1007/s11280-023-01171-1

[Cat259] Tayeh T, Aburakhia S, Myers R, et al (2022) An attention-based ConvLSTM autoencoder with dynamic thresholding for unsupervised anomaly detection in multivariate time series. Mach Learn Knowl Extr 4(2):350–370. https://doi.org/10.3390/make4020015

[Cat260] Theissler A, Wengert M, Gerschner F (2023) ROCKAD: Transferring rocket to whole time series anomaly detection. In: Adv. Intell. Data Anal. XXI (IDA'23), p 419–432, https://doi.org/10.1007/978-3-031-30047-9_33

[Cat261] Tian Y, Gao R, Yan L, et al (2023a) Dynamic graph learning with long and short-term for multivariate time series anomaly detection. In: Proc. IEEE Int. Conf. Intell. Data Acquis. Adv. Comput. Syst.: Technol. Appl. (IDAACS'23), pp 1065–1070, https://doi.org/10.1109/IDAACS58523.2023.10348896

[Cat262] Tian Y, Xu J, Zuo J, et al (2024) AgileAD: Anchor-guided contrastive learning with a general data augmentation strategy for time series anomaly detection. In: IEEE Int. Conf. Tools Artif. Intell. (ICTAI'24), pp 573–577, https://doi.org/10.1109/ICTAI62512.2024.00086

[Cat263] Tian Z, Zhuo M, Liu L, et al (2023b) Anomaly detection using spatial and temporal information in multivariate time series. Sci Rep 13(1). https://doi.org/10.1038/s41598-023-31193-8

[Cat264] Tu FF, Liu DJ, Yan ZW, et al (2024) STFT-TCAN: A tcn-attention based multivariate time series anomaly detection architecture with time-frequency analysis for cyber-industrial systems. Comput Secur 144. https://doi.org/10.1016/j.cose.2024.103961

[Cat265] Tuli S, Casale G, Jennings NR (2022) TranAD: deep transformer networks for anomaly detection in multivariate time series data. Proc VLDB Endow 15(6):1201–1214. https://doi.org/10.14778/3514061.3514067

[Cat266] Wang C, Liu G (2024) From anomaly detection to classification with graph attention and transformer for multivariate time series. Adv Eng Inform 60. https://doi.org/10.1016/j.aei.2024.102357

[Cat267] Wang C, Xing S, Gao R, et al (2023a) Disentangled dynamic deviation transformer networks for multivariate time series anomaly detection. Sensors 23(3). https://doi.org/10.3390/s23031104

[Cat268] Wang C, Zhuang Z, Qi Q, et al (2023b) Drift doesn't matter: dynamic decomposition with diffusion reconstruction for unstable multivariate time series anomaly detection. In: Adv. Neural Inf. Process. Syst. (NeurIPS'23), pp 10758–10774, URL https://papers.nips.cc/paper_files/paper/2023/hash/22f5d8e689d2a011cd8ead552ed59052-Abstract-Conference.html

[Cat269] Wang F, Wang K, Yao B (2023c) Time series anomaly detection with reconstruction-based state-space models. In: Artif. Neural Netw. Mach. Learn. (ICANN'23), p 74–86, https://doi.org/10.1007/978-3-031-44213-1_7

[Cat270] Wang F, Yan M, Li Q, et al (2023d) A multivariate time series anomaly detection model based on spatio-temporal dual features. In: IEEE Int. Conf. Netw. Netw. Appl. (NaNA'23), pp 416–421, https://doi.org/10.1109/NaNA60121.2023.00075

[Cat271] Wang J, Shao S, Bai Y, et al (2023e) Multiscale wavelet graph autoencoder for multivariate time-series anomaly detection. IEEE Trans Instrum Meas 72:1–11. https://doi.org/10.1109/TIM.2022.3223142

[Cat272] Wang J, Zhang H, Miao Q (2024a) An attention graph stacked autoencoder for anomaly detection of electro-mechanical actuator using spatio-temporal multivariate signals. Chin J Aeronaut 37(9):506–520. https://doi.org/10.1016/j.cja.2024.03.024

[Cat273] Wang J, Zhao D, Zhao G (2024b) Malicious participants and fake task detection incorporating gaussian bias. ACM Trans Internet Technol 24(4). https://doi.org/10.1145/3696419, URL https://doi.org/10.1145/3696419

[Cat274] Wang K, Zheng H, Li Y, et al (2022a) AGAPE: Anomaly detection with generative adversarial network for improved performance, energy, and security in manycore systems. In: Des. Autom. Test Eur. Conf. Exhib. (DATE'22), pp 849–854, https://doi.org/10.23919/DATE54114.2022.9774693

[Cat275] Wang L, Lin Y, Wu Y, et al (2021a) Forecast-based multi-aspect framework for multivariate time-series anomaly detection. In: IEEE Int. Conf. Big Data (Big Data'21), pp 938–947, https://doi.org/10.1109/bigdata52589.2021.9671776

[Cat276] Wang L, Xu S, Du X, et al (2024c) DACR: Distribution-augmented contrastive reconstruction for time-series anomaly detection. IEEE Int Conf Acoust Speech Signal Process (ICASSP'24) pp 7545–7549. https://doi.org/10.1109/ICASSP48485.2024.10447891

[Cat277] Wang M, Rong C, Sun H (2023f) Multi-type anomaly detection using one deep neural model for qar data. In: IEEE Int. Conf. Civ. Aviat. Saf. Inf. Technol. (ICCASIT'23), pp 700–706, https://doi.org/10.1109/ICCASIT58768.2023.10351536

[Cat278] Wang R, Zhan J, Sun Y (2023g) Spatial-temporal graph neural network based anomaly detection. In: Adv. Comput. Sci. Eng. Educ. VI (ICCSEEA'23), p 459–471, https://doi.org/10.1007/978-3-031-36118-0_42

[Cat279] Wang W, Peng Z, Wang S, et al (2021b) IFP-ADAC: A two-stage interpretable fault prediction model for multivariate time series. In: IEEE Int. Conf. Mob. Data Manag. (MDM'21), pp 29–38, https://doi.org/10.1109/MDM52706.2021.00017

[Cat280] Wang W, Chen P, Xu Y, et al (2022b) Active-MTSAD: Multivariate time series anomaly detection with active learning. In: IEEE/IFIP Int. Conf. Dependable Syst. Netw. (DSN'22), pp 263–274, https://doi.org/10.1109/DSN53405.2022.00036

[Cat281] Wang W, Zuo E, Wang R, et al (2024d) Bi-branching feature interaction representation learning for multivariate time series. Appl Soft Comput 167. https://doi.org/10.1016/j.asoc.2024.112383

[Cat282] Wang X, Pi D, Zhang X, et al (2022c) Variational transformer-based anomaly detection approach for multivariate time series. Measurement 191. https://doi.org/https://doi.org/10.1016/j.measurement.2022.110791

[Cat283] Wang X, Xing Q, Xiao H, et al (2024e) Contrastive learning enhanced by graph neural networks for universal multivariate time series representation. Inf Syst 125. https://doi.org/10.1016/j.is.2024.102429

[Cat284] Wang Y, Sun H, Wang C, et al (2024f) Interdependency matters: Graph alignment for multivariate time series anomaly detection. In: IEEE Int. Conf. Data Min. (ICDM'24), p 869–874, https://doi.org/10.1109/icdm59182.2024.00107

[Cat285] Wei D, Sun W, Zou X, et al (2024) An anomaly detection model for multivariate time series with anomaly perception. PeerJ Comput Sci 10. https://doi.org/10.7717/peerj-cs.2172

[Cat286] Weldezgina Asres M, Cummings G, Parygin P, et al (2021) Unsupervised deep variational model for multivariate sensor anomaly detection. In: IEEE Int. Conf. Prog. Inform. Comput. (PIC'21), pp 364–371, https://doi.org/10.1109/PIC53636.2021.9687034

[Cat287] Wen P, Yang Z, Wu L, et al (2022) A novel convolutional adversarial framework for multivariate time series anomaly detection and explanation in cloud environment. Appl Sci 12(20). https://doi.org/10.3390/app122010390

[Cat288] Wu H, Hu T, Liu Y, et al (2023a) TimesNet: Temporal 2d-variation modeling for general time series analysis. In: Int. Conf. Learn. Represent. (ICLR'23), URL https://openreview.net/forum?id=ju_Uqw384Oq

[Cat289] Wu H, Yang R, Qing H, et al (2023b) TSFN: an effective time series anomaly detection approach via transformer-based self-feedback network. In: IEEE Int. Conf. Comput. Support. Coop. Work Des. (CSCWD'23), pp 1396–1401, https://doi.org/10.1109/CSCWD57460.2023.10152838

[Cat290] Wu J, Yao L, Liu B, et al (2021) Multi-task learning based encoder-decoder: A comprehensive detection and diagnosis system for multi-sensor data. Adv Mech Eng 13(5). https://doi.org/10.1177/16878140211013138

[Cat291] Wu Y, Gu M, Wang L, et al (2022) Event2Graph: Event-driven bipartite graph for multivariate time-series anomaly detection. In: Proc. Workshop Appl. Mach. Learn. Methods Time Ser. Forecast. (AMLTS'22@CIKM), https://doi.org/https://doi.org/10.48550/arXiv.2108.06783

[Cat292] Wu YX, Dai BR (2024) STL-ConvTransformer: Series decomposition and convolution-infused transformer architecture in multivariate time series anomaly detection. In: Adv. Knowl. Discov. Data Min. (PAKDD'24), pp 41–52, https://doi.org/10.1007/978-981-97-2242-6_4

[Cat293] Xia F, Chen X, Yu S, et al (2024a) Coupled attention networks for multivariate time series anomaly detection. IEEE Trans Emerg Top Comput 12(1):240–253. https://doi.org/10.1109/TETC.2023.3280577

[Cat294] Xia S, Sun W, Zou X, et al (2024b) MFAM-AD: an anomaly detection model for multivariate time series using attention mechanism to fuse multi-scale features. PeerJ Comput Sci 10. https://doi.org/10.7717/peerj-cs.2201

[Cat295] Xie J, Cui Y, Huang F, et al (2022) MARINA: An MLP-attention model for multivariate time-series analysis. In: Proc. ACM Int. Conf. Inf. Knowl. Manag. (CIKM'22), p 2230–2239, https://doi.org/10.1145/3511808.3557386

[Cat296] Xie S, Li L, Zhu Y (2024a) Anomaly detection for multivariate time series in iot using discrete wavelet decomposition and dual graph attention networks. Comput Secur 146. https://doi.org/10.1016/j.cose.2024.104075

[Cat297] Xie T, Xu Q, Jiang C (2023) Anomaly detection for multivariate times series through the multi-scale convolutional recurrent variational autoencoder. Expert Syst Appl 231. https://doi.org/10.1016/j.eswa.2023.120725

[Cat298] Xie T, Xu Q, Jiang C, et al (2024b) A robust anomaly detection model for pumps based on the spectral residual with self-attention variational autoencoder. IEEE Trans Ind Informat 20(6):9059–9069. https://doi.org/10.1109/TII.2024.3381790

[Cat299] Xing S, Niu J, Ren T (2023) GCFormer: Granger causality based attention mechanism for multivariate time series anomaly detection. In: IEEE Int. Conf. Data Min. (ICDM'23), pp 1433–1438, https://doi.org/10.1109/ICDM58522.2023.00187

[Cat300] Xing Y, Liu D, Bao Y (2024) Industrial anomaly detection based on factorized temporal-channel fusion. IEEE Sens J 24(21):34977–34986. https://doi.org/10.1109/JSEN.2024.3452955

[Cat301] Xiong W, Wang P, Sun X, et al (2024) SiET: Spatial information enhanced transformer for multivariate time series anomaly detection. Knowl-Based Syst 296. https://doi.org/10.1016/j.knosys.2024.111928

[Cat302] Xiong Y, Wang J, Xin Y, et al (2023) An attention mechanism based approach for multivariate time series anomaly detection. In: IEEE Int. Conf. Dependable Syst. Their Appl. (DSA'23), pp 173–181, https://doi.org/10.1109/DSA59317.2023.00030

[Cat303] Xiong Z, Fan Q, Wang K, et al (2022) PRAD: Unsupervised kpi anomaly detection by joint prediction and reconstruction of multivariate time series. In: IEEE Smartworld, Ubiquitous Intell. & Comput., Scal. Comput. & Commun., Digit. Twin, Privacy Comput., Metaverse, Auton. & Trusted Veh. (SmartWorld/UIC/ScalCom/DigitalTwin/PriComp/Meta'22), pp 384–391, https://doi.org/10.1109/SmartWorld-UIC-ATC-ScalCom-DigitalTwin-PriComp-Metaverse56740.2022.00075

[Cat304] Xu H, Lou Y (2023) Multivariate time series anomaly detection: a hybrid method based on GRU-SAE and GAIN. In: IEEE Inf. Technol. Netw. Electron. Autom. Control Conf. (ITNEC'23), pp 32–38, https://doi.org/10.1109/ITNEC56291.2023.10082407

[Cat305] Xu J, Wu H, Wang J, et al (2022) Anomaly Transformer: Time series anomaly detection with association discrepancy. In: Int. Conf. Learn. Represent. (ICLR'22), https://doi.org/https://doi.org/10.48550/arXiv.2110.02642

[Cat306] Xu K, Li Y, Li Y, et al (2023a) Masked graph neural networks for unsupervised anomaly detection in multivariate time series. Sensors 23(17). https://doi.org/10.3390/s23177552

[Cat307] Xu L, Ding X, Zhao D, et al (2023b) A three-dimensional resnet and transformer-based approach to anomaly detection in multivariate temporal–spatial data. Entropy 25(2). https://doi.org/10.3390/e25020180

[Cat308] Xu Q, Xie T, Jiang C, et al (2024a) Adaptive working condition recognition with clustering-based contrastive learning for unsupervised anomaly detection. IEEE Trans Ind Informat 20(10):12103–12113. https://doi.org/10.1109/TII.2024.3413952

[Cat309] Xu Y, Ding Y, Jiang J, et al (2024b) Skip-patching spatial–temporal discrepancy-based anomaly detection on multivariate time series. Neurocomputing 609. https://doi.org/10.1016/j.neucom.2024.128428

[Cat310] Xu Z, Yang Y, Gao X, et al (2023c) DCFF-MTAD: A multivariate time-series anomaly detection model based on dual-channel feature fusion. Sensors 23(8). https://doi.org/10.3390/s23083910

[Cat311] Xue B, Gao X, Zhai F, et al (2023) A contrastive autoencoder with multi-resolution segment-consistency discrimination for multivariate time series

anomaly detection. Appl Intell 53(23):28655–28674. https://doi.org/10.1007/s10489-023-04985-8

[Cat312] Xue B, Gao X, Li B, et al (2024) A robust multi-scale feature extraction framework with dual memory module for multivariate time series anomaly detection. Neural Netw 177. https://doi.org/10.1016/j.neunet.2024.106395

[Cat313] Xue Y (2023) Research on time series anomaly detection based on graph neural network. In: IEEE Int. Conf. Electr. Automat. Comput. Eng. (ICEACE'23), pp 1670–1674, https://doi.org/10.1109/ICEACE60673.2023.10442027

[Cat314] Yan H, Li F, Chen J, et al (2023) A graph embedded in graph framework with dual-sequence input for efficient anomaly detection of complex equipment under insufficient samples. Reliab Eng Syst Saf 238. https://doi.org/10.1016/j.ress.2023.109418

[Cat315] Yan W (2019) Detecting gas turbine combustor anomalies using semi-supervised anomaly detection with deep representation learning. Cogn Comput 12(2):398–411. https://doi.org/10.1007/s12559-019-09710-7

[Cat316] Yang B, Long W, Zhang Y, et al (2024a) Multivariate time series anomaly detection: Missing data handling and feature collaborative analysis in robot joint data. J Manuf Syst 75:132–149. https://doi.org/10.1016/j.jmsy.2024.06.006

[Cat317] Yang J, Yue Z (2023) Learning hierarchical spatial-temporal graph representations for robust multivariate industrial anomaly detection. IEEE Trans Ind Informat 19(6):7624–7635. https://doi.org/10.1109/TII.2022.3216006

[Cat318] Yang J, Yue Z, Yuan Y (2023a) Deep probabilistic graphical modeling for robust multivariate time series anomaly detection with missing data. Reliab Eng Syst Saf 238. https://doi.org/https://doi.org/10.1016/j.ress.2023.109410

[Cat319] Yang K, Dou S, Luo P, et al (2022) Robust group anomaly detection for quasi-periodic network time series. IEEE Trans Netw Sci Eng 9(4):2833–2845. https://doi.org/10.1109/tnse.2022.3170364

[Cat320] Yang L, Zhang Z (2021) Wind turbine gearbox failure detection based on scada data: A deep learning-based approach. IEEE Trans Instrum Meas 70:1–11. https://doi.org/10.1109/TIM.2020.3045800

[Cat321] Yang Q, Zhang J, Zhang J, et al (2024b) Graph transformer network incorporating sparse representation for multivariate time series anomaly detection. Electronics 13(11). https://doi.org/10.3390/electronics13112032

[Cat322] Yang S, Li J, Shi K, et al (2024c) Spatial-temporal interaction decoding transformer for unsupervised multivariate time series anomaly detection. In: IEEE Int. Conf. Acoust. Speech Signal Process. (ICASSP'24), pp 5440–5444, https://doi.org/

10.1109/ICASSP48485.2024.10448347

[Cat323] Yang X, Li H, Feng X, et al (2023b) Variable-wise generative adversarial transformer in multivariate time series anomaly detection. Appl Intell 53(23):28745–28767. https://doi.org/10.1007/s10489-023-05029-x

[Cat324] Yang Y, Zhang C, Zhou T, et al (2023c) DCdetector: Dual attention contrastive representation learning for time series anomaly detection. In: Proc. ACM SIGKDD Int. Conf. Knowl. Discov. Data Min. (KDD '23), pp 3033–3045, https://doi.org/10.1145/3580305.3599295

[Cat325] Yang Y, Li Z, Lin P, et al (2024d) Characteristic-aware time-series representation learning for unsupervised anomaly detection. In: IEEE Int. Jt. Conf. Neural Netw. (IJCNN'24), pp 1–9, https://doi.org/10.1109/IJCNN60899.2024.10650866

[Cat326] Yao H, Liu D, Chang Y, et al (2024a) Time series anomaly detection based on normalized flow and bayesian networks. In: IEEE Int. Conf. Data Sci. Cyberspace (DSC'24), pp 515–522, https://doi.org/10.1109/DSC63484.2024.00077

[Cat327] Yao Y, Ma J, Feng S, et al (2024b) SVD-AE: An asymmetric autoencoder with svd regularization for multivariate time series anomaly detection. Neural Netw 170:535–547. https://doi.org/10.1016/j.neunet.2023.11.023

[Cat328] Yassine M, Théo F (2023) Anomaly detection for industrial sensors using transformers. In: IEEE Int. Conf. Future Internet Things Cloud (FiCloud'23), pp 167–174, https://doi.org/10.1109/FiCloud58648.2023.00032

[Cat329] Ye Y, Feng B, Tao W (2021) MILAD: Robust anomaly detection for electric vehicles with label noise. J Phys: Conf Ser 2132(1). https://doi.org/10.1088/1742-6596/2132/1/012047

[Cat330] Ye Y, He Q, Zhang P, et al (2023) Multivariate time series anomaly detection with fourier time series transformer. In: IEEE Int. Conf. Cloud Netw. (CloudNet'23), pp 381–388, https://doi.org/10.1109/CloudNet59005.2023.10490086

[Cat331] Yi S, Zheng S, Yang S, et al (2024) Anomaly detection for asynchronous multivariate time series of nuclear power plants using a temporal-spatial transformer. Sensors 24(9). https://doi.org/10.3390/s24092845

[Cat332] Yokkampon U, Mowshowitz A, Chumkamon S, et al (2022) Robust unsupervised anomaly detection with variational autoencoder in multivariate time series data. IEEE Access 10:57835–57849. https://doi.org/10.1109/ACCESS.2022.3178592

[Cat333] Yu B, Yu Y, Xiang G, et al (2024a) Triple Attention: An integrated approach for interpretable anomaly detection in temporal and association dimensions. IEEE Trans Instrum Meas 73:1–12. https://doi.org/10.1109/TIM.2024.3460930

[Cat334] Yu B, Yu Y, Xu J, et al (2024b) MAG: A novel approach for effective anomaly detection in spacecraft telemetry data. IEEE Trans Ind Informat 20(3):3891–3899. https://doi.org/10.1109/TII.2023.3314852

[Cat335] Yu J, Song Y, Tang D, et al (2021) Telemetry data-based spacecraft anomaly detection with spatial–temporal generative adversarial networks. IEEE Trans Instrum Meas 70:1–9. https://doi.org/10.1109/TIM.2021.3073442

[Cat336] Yu J, Gao X, Li B, et al (2024c) A filter-augmented auto-encoder with learnable normalization for robust multivariate time series anomaly detection. Neural Netw 170:478–493. https://doi.org/10.1016/j.neunet.2023.11.047

[Cat337] Yu J, Gao X, Zhai F, et al (2024d) An adversarial contrastive autoencoder for robust multivariate time series anomaly detection. Expert Syst Appl 245. https://doi.org/10.1016/j.eswa.2023.123010

[Cat338] Yu Lr, Lu Qh, Xue Y (2024e) DTAAD: Dual tcn-attention networks for anomaly detection in multivariate time series data. Knowl-Based Syst 295. https://doi.org/10.1016/j.knosys.2024.111849, URL http://dx.doi.org/10.1016/j.knosys.2024.111849

[Cat339] Yu P, Zhou X, Chen L, et al (2023) Anomaly detection model for data interactions based on temporal features in electric power data centers. In: IEEE Int. Conf. Commun. Image Signal Process. (CCISP'23), pp 580–586, https://doi.org/10.1109/CCISP59915.2023.10355803

[Cat340] Yu R, Wang Y, Wang W (2024f) AMAD: Active learning-based multivariate time series anomaly detection for large-scale it systems. Comput Secur 137. https://doi.org/10.1016/j.cose.2023.103603

[Cat341] Yu YC, Ouyang YC, Wu LW, et al (2024g) Multivariate time-series anomaly detection in IoT with a bi-dual GM GRU autoencoder. In: IEEE Comput. Softw. Appl. Conf. (COMPSAC'24), pp 746–754, https://doi.org/10.1109/COMPSAC61105.2024.00106

[Cat342] Yuan A, Zou C, Wang Y, et al (2024a) Multivariate time series anomaly detection based on time-frequency dynamic analysis. In: IEEE Int. Conf. Commun. Circuits Syst. (ICCCAS'24), pp 375–379, https://doi.org/10.1109/ICCCAS62034.2024.10652754

[Cat343] Yuan X, Ning K, Wei K, et al (2024b) A hybrid MTS anomaly detection method based on reconstruction and adaptive spatial-temporal graph network. In: IEEE Data Driven Control Learn. Syst. Conf. (DDCLS'24), pp 263–267, https://doi.org/10.1109/DDCLS61622.2024.10606793

[Cat344] Yue Z, Wang Y, Duan J, et al (2022) TS2Vec: Towards universal representation of time series. In: Proc. AAAI Conf. Artif. Intell. (AAAI'22), pp 8980–8987, https:

//doi.org/10.1609/aaai.v36i8.20881

[Cat345] Zeng F, Chen M, Qian C, et al (2023) Multivariate time series anomaly detection with adversarial transformer architecture in the internet of things. Future Gener Comput Syst 144:244–255

[Cat346] Zeng Z, Lei J, Jin G, et al (2022) Detecting anomalies in satellite telemetry data based on causal multivariate temporal convolutional network. In: IEEE Int. Conf. Big Data Artif. Intell. (BDAI'22), pp 63–74, https://doi.org/10.1109/BDAI56143.2022.9862616

[Cat347] Zhan J, Wang S, Ma X, et al (2022a) STGAT-MAD: Spatial-temporal graph attention network for multivariate time series anomaly detection. In: IEEE Int. Conf. Acoust. Speech Signal Process. (ICASSP'22), pp 3568–3572, https://doi.org/10.1109/ICASSP43922.2022.9747274

[Cat348] Zhan J, Wu C, Ma X, et al (2022b) Abnormal vibration detection of wind turbine based on temporal convolution network and multivariate coefficient of variation. Mech Syst Signal Process 174. https://doi.org/https://doi.org/10.1016/j.ymssp.2022.109082

[Cat349] Zhan J, Wu C, Yang C, et al (2024) HFN: Heterogeneous feature network for multivariate time series anomaly detection. Inf Sci 670. https://doi.org/10.1016/j.ins.2024.120626

[Cat350] Zhang A, Zhao X, Wang L (2021a) CNN and LSTM based encoder-decoder for anomaly detection in multivariate time series. In: IEEE Inf. Technol. Netw. Electron. Autom. Control Conf. (ITNEC'21), pp 571–575, https://doi.org/10.1109/ITNEC52019.2021.9587207

[Cat351] Zhang C, Song D, Chen Y, et al (2019) A deep neural network for unsupervised anomaly detection and diagnosis in multivariate time series data. In: Proc. AAAI Conf. Artif. Intell. (AAAI'19), pp 1409–1416, https://doi.org/10.1609/aaai.v33i01.33011409

[Cat352] Zhang C, Zhou T, Wen Q, et al (2022a) TFAD: A decomposition time series anomaly detection architecture with time-frequency analysis. In: Proc. ACM Int. Conf. Inf. Knowl. Manag. (CIKM'22), pp 2497–2507, https://doi.org/10.1145/3511808.3557470

[Cat353] Zhang C, Li Y, Li J, et al (2023a) Multivariate time series anomaly detection method based on mTranAD. In: Adv. Intell. Comput. Technol. Appl. (ICIC'23), p 52–63, https://doi.org/10.1007/978-981-99-4752-2_5

[Cat354] Zhang C, Wu S, Gao M, et al (2024a) Anomaly detection method for multivariate time series data based on BLTranAD. In: Adv. Intell. Comput. Technol. Appl. (ICIC'24), p 16–26, https://doi.org/10.1007/978-981-97-5618-6_2

[Cat355] Zhang G, Gao X, Wang L, et al (2022b) Probabilistic autoencoder with multi-scale feature extraction for multivariate time series anomaly detection. Appl Intell 53(12):15855–15872. https://doi.org/10.1007/s10489-022-04324-3

[Cat356] Zhang H, Xia Y, Yan T, et al (2021b) Unsupervised anomaly detection in multivariate time series through transformer-based variational autoencoder. In: IEEE Chin. Control Decis. Conf. (CCDC'21), pp 281–286, https://doi.org/10.1109/CCDC52312.2021.9601669

[Cat357] Zhang H, Wang Y, Han Q (2024b) USTG:multivariate time series anomaly detection via unsupervised spatial-temporal graph learning. In: IEEE Int. Conf. Behav. Soc. Comput. (BESC'24), pp 1–6, https://doi.org/10.1109/BESC64747.2024.10780512

[Cat358] Zhang J, Wang C, Zhang X, et al (2022c) Multi-attention integrated convolutional network for anomaly detection of time series. In: IEEE Int. Conf. Comput. Autom. Eng. (ICCAE'22), pp 91–96, https://doi.org/10.1109/iccae55086.2022.9762449

[Cat359] Zhang K, Jiang Y, Seversky L, et al (2021c) Federated variational learning for anomaly detection in multivariate time series. In: IEEE Int. Perform. Comput. Commun. Conf. (IPCCC'21), pp 1–9, https://doi.org/10.1109/IPCCC51483.2021.9679367

[Cat360] Zhang K, Li C, Yang Q, et al (2023b) Segmentation-based adversarial denoising auto-encoder for anomaly detection in multivariate time series data. In: IEEE Int. Conf. Inf. Sci. Technol. (ICIST'23), pp 608–615, https://doi.org/10.1109/ICIST59754.2023.10367117

[Cat361] Zhang L, Bai W, Xie X, et al (2024c) TMANomaly: Time-series mutual adversarial networks for industrial anomaly detection. IEEE Trans Ind Informat 20(2):2263–2271. https://doi.org/10.1109/TII.2023.3288226

[Cat362] Zhang M, Shi X, Huang J, et al (2024d) DynTrackr: A robust two-stage framework with attribute enhancement for kpi anomaly detection. In: IEEE Int. Symp. Softw. Reliab. Eng. Workshops (ISSREW'24), pp 169–176, https://doi.org/10.1109/ISSREW63542.2024.00069

[Cat363] Zhang R, Chen J, Song Y, et al (2023c) An effective transformation-encoding-attention framework for multivariate time series anomaly detection in iot environment. Mobile Netw Appl 29(5):1551–1563. https://doi.org/10.1007/s11036-023-02204-9

[Cat364] Zhang S, Liu J (2023) Multivariate time series anomaly detection based on graph neural network for big data scheduling system. In: Web Inf. Syst. Eng. (WISE'23), p 791–800, https://doi.org/10.1007/978-981-99-7254-8_61

[Cat365] Zhang S, Chen X, Chen J, et al (2020) Anomaly detection of periodic multivariate time series under high acquisition frequency scene in iot. In: IEEE Int. Conf. Data Min. Workshops (ICDMW'20), pp 543–552, https://doi.org/10.1109/ICDMW51313.2020.00078

[Cat366] Zhang W, Zhang C, Tsung F (2022d) GRELEN: Multivariate time series anomaly detection from the perspective of graph relational learning. In: Proc. Int. Jt. Conf. Artif. Intell. (IJCAI'22), pp 2390–2397, https://doi.org/10.24963/ijcai.2022/332

[Cat367] Zhang W, He P, Li T, et al (2023d) A memory-guided anomaly detection model with contrastive learning for multivariate time series. Comput Mater Continua 77(2):1893–1910. https://doi.org/10.32604/cmc.2023.044253

[Cat368] Zhang W, Wang Y, Chen L, et al (2023e) Dynamic circular network-based federated dual-view learning for multivariate time series anomaly detection. Bus Inf Syst Eng 66(1):19–42. https://doi.org/10.1007/s12599-023-00825-8

[Cat369] Zhang W, He P, Qin C, et al (2024e) A graph attention network-based model for anomaly detection in multivariate time series. J Supercomput 80(6):8529–8549. https://doi.org/10.1007/s11227-023-05772-5

[Cat370] Zhang W, Xu J, Liu Y, et al (2024f) Anomaly identification of flight test time series data based on improved LSTM. In: IEEE Int. Conf. Electr. Mech. Comput. Eng. (ICEMCE'24), p 1044–1050, https://doi.org/10.1109/icemce64157.2024.10862782

[Cat371] Zhang X, Wang C, Zhang J, et al (2022e) Attention based CNN-LSTM network for anomaly pattern classification of multivariate time series. In: IEEE Data Driven Control Learn. Syst. Conf. (DDCLS'22), pp 1015–1020, https://doi.org/10.1109/ddcls55054.2022.9858500

[Cat372] Zhang X, Zhang J, Wang C, et al (2022f) CANet: Convolutional attention-based network for multivariate time series anomaly detection. In: IEEE Int. Conf. Intell. Comput. Signal Process. (ICSP'22), pp 1625–1630, https://doi.org/10.1109/icsp54964.2022.9778305

[Cat373] Zhang X, Zhao Z, Tsiligkaridis T, et al (2022g) Self-supervised contrastive pre-training for time series via time-frequency consistency. In: Adv. Neural Inf. Process. Syst. (NeurIPS'22), pp 3988–4003, URL https://papers.nips.cc/paper_files/paper/2022/hash/194b8dac525581c346e30a2cebe9a369-Abstract-Conference.html

[Cat374] Zhang X, Shi S, Sun H, et al (2024g) ACVAE: A novel self-adversarial variational auto-encoder combined with contrast learning for time series anomaly detection. Neural Netw 171:383–395. https://doi.org/10.1016/j.neunet.2023.12.023

[Cat375] Zhang X, Xu S, Chen H, et al (2024h) Rethinking robust multivariate time series anomaly detection: A hierarchical spatio-temporal variational perspective.

IEEE Trans Knowl Data Eng 36(12):9136–9149. https://doi.org/10.1109/TKDE.2024.3466291

[Cat376] Zhang Y, Chen Y, Wang J, et al (2023f) Unsupervised deep anomaly detection for multi-sensor time-series signals. IEEE Trans Knowl Data Eng 35(2):2118–2132. https://doi.org/10.1109/TKDE.2021.3102110

[Cat377] Zhang Y, Li B, Zhang X (2023g) Deep learning-based anomaly detection for time-series data in industrial control systems. In: IEEE Chin. Control Conf. (CCC'23), pp 8825–8829, https://doi.org/10.23919/CCC58697.2023.10241095

[Cat378] Zhang Y, Wang J, Chen Y, et al (2023h) Adaptive memory networks with self-supervised learning for unsupervised anomaly detection. IEEE Trans Knowl Data Eng 35(12):12068–12080. https://doi.org/10.1109/tkde.2021.3139916

[Cat379] Zhang Z, Chen Y, Wang H, et al (2023i) Anomaly detection method for building energy consumption in multivariate time series based on graph attention mechanism. PLOS ONE 18(6). https://doi.org/10.1371/journal.pone.0286770

[Cat380] Zhang Z, Li W, Ding W, et al (2023j) STAD-GAN: Unsupervised anomaly detection on multivariate time series with self-training generative adversarial networks. ACM Trans Knowl Discov Data 17(5). https://doi.org/10.1145/3572780

[Cat381] Zhang Z, Geng Z, Han Y (2024i) Graph structure change-based anomaly detection in multivariate time series of industrial processes. IEEE Trans Ind Informat 20(4):6457–6466. https://doi.org/10.1109/TII.2023.3347000

[Cat382] Zhang Z, Yao Y, Hutabarat W, et al (2024j) Time series anomaly detection in vehicle sensors using self-attention mechanisms. IEEE Trans Intell Transp Syst 25(11):15964–15976. https://doi.org/10.1109/TITS.2024.3415435

[Cat383] Zhao B, Nie J, Guan S, et al (2022a) Hierarchical feature fusion based reconstruction network for unsupervised anomaly detection. In: IEEE Int. Conf. Emerg. Technol. Fact. Autom. (ETFA'22), pp 1–6, https://doi.org/10.1109/ETFA52439.2022.9921590

[Cat384] Zhao H, Wang Y, Duan J, et al (2020) Multivariate time-series anomaly detection via graph attention network. In: IEEE Int. Conf. Data Min. (ICDM'20), pp 841–850, https://doi.org/10.1109/ICDM50108.2020.00093

[Cat385] Zhao M, Fink O (2024) Dyedgegat: Dynamic edge via graph attention for early fault detection in iiot systems. IEEE Internet Things J 11(13):22950–22965. https://doi.org/10.1109/JIOT.2024.3381002

[Cat386] Zhao M, Peng H, Li L, et al (2024a) Graph attention network and informer for multivariate time series anomaly detection. Sensors 24(5). https://doi.org/10.3390/s24051522

[Cat387] Zhao M, Peng H, Li L, et al (2024b) Multivariate time series anomaly detection based on spatial-temporal network and transformer in industrial internet of things. Comput Mater Contin 80(2):2815–2837. https://doi.org/10.32604/cmc.2024.053765

[Cat388] Zhao P, Chang X, Wang M (2021) A novel multivariate time-series anomaly detection approach using an unsupervised deep neural network. IEEE Access 9:109025–109041. https://doi.org/10.1109/access.2021.3101844

[Cat389] Zhao T, Jin L, Zhou X, et al (2023) Unsupervised anomaly detection approach based on adversarial memory autoencoders for multivariate time series. Comput Mater Contin 76(1):329–346. https://doi.org/10.32604/cmc.2023.038595

[Cat390] Zhao X, Chen W, Yin Q, et al (2022b) Bidirectional deep variational rnn for refining anomaly detection of multivariate time series. In: IEEE Jt. Int. Inf. Technol. & Artif. Intell. Conf. (ITAIC'22), pp 1504–1509, https://doi.org/10.1109/ITAIC54216.2022.9836567

[Cat391] Zhao X, Liu P, Mahmoudi S, et al (2024c) DDANF: Deep denoising autoencoder normalizing flow for unsupervised multivariate time series anomaly detection. Alex Eng J 108:436–444. https://doi.org/10.1016/j.aej.2024.07.013

[Cat392] Zheng B, Ming L, Zeng K, et al (2024a) Adversarial graph neural network for multivariate time series anomaly detection. IEEE Trans Knowl Data Eng 36(12):7612–7626. https://doi.org/10.1109/TKDE.2024.3419891

[Cat393] Zheng J, Duan J, Zhang K, et al (2024b) Multi-scale deep convolutional time series anomaly detection based on correlation matrix. In: IEEE Int. Symp. Comput. Inf. Process. Technol. (ISCIPT'24), pp 613–617, https://doi.org/10.1109/iscipt61983.2024.10672758

[Cat394] Zheng M, Man J, Wang D, et al (2023) Semi-supervised multivariate time series anomaly detection for wind turbines using generator scada data. Reliab Eng Syst Saf 235. https://doi.org/https://doi.org/10.1016/j.ress.2023.109235

[Cat395] Zheng W (2022) Anomaly detection of multivariate industrial sensing data based on graph attention network. In: IEEE Int. Conf. Smart City Informat. (iSCI'22), pp 14–21, https://doi.org/10.1109/iSCI57775.2022.00012

[Cat396] Zheng Y, Koh HY, Jin M, et al (2024c) Correlation-aware spatial–temporal graph learning for multivariate time-series anomaly detection. IEEE Trans Neural Netw Learn Syst 35(9):11802–11816. https://doi.org/10.1109/TNNLS.2023.3325667

[Cat397] Zheng Y, Koh HY, Jin M, et al (2024d) Graph spatiotemporal process for multivariate time series anomaly detection with missing values. Inf Fusion 106. https://doi.org/10.1016/j.inffus.2024.102255

[Cat398] Zhou B, Liu S, Hooi B, et al (2019) BeatGAN: anomalous rhythm detection using adversarially generated time series. In: Proc. Int. Jt. Conf. Artif. Intell., IJCAI'19, pp 4433–4439, https://doi.org/10.24963/ijcai.2019/616

[Cat399] Zhou H, Yu K, Zhang X, et al (2022a) Contrastive autoencoder for anomaly detection in multivariate time series. Inf Sci 610:266–280. https://doi.org/10.1016/j.ins.2022.07.179

[Cat400] Zhou L, Zeng Q, Li B (2022b) Hybrid anomaly detection via multihead dynamic graph attention networks for multivariate time series. IEEE Access 10:40967–40978. https://doi.org/10.1109/ACCESS.2022.3167640

[Cat401] Zhou Q, Chen J, Liu H, et al (2023a) Detecting multivariate time series anomalies with zero known label. In: Proc. AAAI Conf. Artif. Intell. (AAAI'23), pp 4963–4971, https://doi.org/10.1609/aaai.v37i4.25623

[Cat402] Zhou X, Wang Y, Xu H, et al (2023b) Local-adaptive transformer for multivariate time series anomaly detection and diagnosis. In: IEEE Int. Conf. Syst. Man Cybern. (SMC'23), pp 89–95, https://doi.org/10.1109/SMC53992.2023.10394229

[Cat403] Zhou X, Dai C, Wang W, et al (2024) Global–local association discrepancy for multivariate time series anomaly detection in iiot. IEEE Internet of Things J 11(7):11287–11297. https://doi.org/10.1109/JIOT.2023.3330696

[Cat404] Zhou Y, Song Y, Qian M (2021) Unsupervised anomaly detection approach for multivariate time series. In: IEEE Int. Conf. Softw. Qual. Reliab. Secur. Companion (QRS-C'21), pp 229–235, https://doi.org/10.1109/QRS-C55045.2021.00042

[Cat405] Zhou Y, Wang J, Tang J, et al (2023c) MP-GAN: Cyber-attack detection and localization for cyber-physical systems with multi-process generative adversarial networks*. In: IEEE Int. Conf. Artif. Intell. Things Syst. (AIoTSys'23), pp 186–193, https://doi.org/10.1109/AIoTSys58602.2023.00049

[Cat406] Zhu G, Guo Y, Chen Y (2024a) Mn-gat: Incorporating metric names into metric correlation graphs for anomaly detection. In: IEEE World Conf. Comput. Commun. Technol. (WCCCT'24), pp 98–103, https://doi.org/10.1109/WCCCT60665.2024.10541442

[Cat407] Zhu G, Zhou H, Wang X, et al (2024b) Anomaly detection for coal-fired boiler via adversarial VAE based method. In: IEEE Int. Conf. Mobil. Sens. Netw. (MSN'24), p 1074–1081, https://doi.org/10.1109/msn63567.2024.00148

[Cat408] Zhu W, Li W, Dorsey ER, et al (2023) Unsupervised anomaly detection by densely contrastive learning for time series data. Neural Netw 168:450–458. https://doi.org/10.1016/j.neunet.2023.09.038

[Cat409] Zou C, Yuan A, Hu J (2024) BiLSTM-based anomaly detection in multivariate time series with attention mechanism and dual analysis. In: IEEE Int. Conf. Inf. Syst. Comput. Aided Educ. (ICISCAE'24), pp 379–384, https://doi.org/10.1109/ICISCAE62304.2024.10761506

12 Selected Reviews or Evaluation Papers (2019-2024)

[Rev1] Audibert J, Michiardi P, Guyard F, et al (2022) Do deep neural networks contribute to multivariate time series anomaly detection? Pattern Recognit 132. https://doi.org/https://doi.org/10.1016/j.patcog.2022.108945

[Rev2] Belay MA, Blakseth SS, Rasheed A, et al (2023) Unsupervised anomaly detection for iot-based multivariate time series: Existing solutions, performance analysis and future directions. Sensors 23(5). https://doi.org/10.3390/s23052844

[Rev3] Choi K, Yi J, Park C, et al (2021) Deep learning for anomaly detection in time-series data: Review, analysis, and guidelines. IEEE Access 9:120043–120065. https://doi.org/10.1109/ACCESS.2021.3107975

[Rev4] Correia L, Goos JC, Klein P, et al (2024) Online model-based anomaly detection in multivariate time series: Taxonomy, survey, research challenges and future directions. Eng Appl Artif Intell 138. https://doi.org/10.1016/j.engappai.2024.109323

[Rev5] Fährmann D, Martín L, Sánchez L, et al (2024) Anomaly detection in smart environments: A comprehensive survey. IEEE Access 12:64006–64049. https://doi.org/10.1109/ACCESS.2024.3395051

[Rev6] Garg A, Zhang W, Samaran J, et al (2022) An evaluation of anomaly detection and diagnosis in multivariate time series. IEEE Trans Neural Netw Learn Syst 33(6):2508–2517. https://doi.org/10.1109/tnnls.2021.3105827

[Rev7] Li D, Zhang S, Sun Y, et al (2023) An empirical analysis of anomaly detection methods for multivariate time series. In: IEEE Int. Symp. Softw. Reliab. Eng. (ISSRE'23), pp 57–68, https://doi.org/10.1109/issre59848.2023.00014

[Rev8] Li G, Jung JJ (2023) Deep learning for anomaly detection in multivariate time series: Approaches, applications, and challenges. Inf Fusion 91:93–102. https://doi.org/10.1016/j.inffus.2022.10.008

[Rev9] Orabi M, Tran KP, Thomassey S, et al (2024) Anomaly detection for catalyzing operational excellence in complex manufacturing processes: A survey and perspective. In: Artificial Intelligence for Safety and Reliability Engineering: Methods, Applications, and Challenges, Springer Series in Reliability Engineering, pp 49–78, https://doi.org/10.1007/978-3-031-71495-5_4

[Rev10] Schmidl S, Wenig P, Papenbrock T (2022) Anomaly detection in time series: a comprehensive evaluation. Proc VLDB Endow 15(9):1779–1797. https://doi.org/10.14778/3538598.3538602

[Rev11] Usmani UA, Abdul Aziz I, Jaafar J, et al (2024) Deep learning for anomaly detection in time-series data: An analysis of techniques, review of applications, and guidelines for future research. IEEE Access 12:174564–174590. https://doi.org/10.1109/access.2024.3495819

[Rev12] Zamanzadeh Darban Z, Webb GI, Pan S, et al (2024) Deep learning for time series anomaly detection: A survey. ACM Comput Surv 57(1). https://doi.org/10.1145/3691338

190 Validation Papers (2025)

[Val1] Abilasha S, Bhadra S (2025) Warping resilient robust anomaly detection for multivariate time series. Mach Learn 114(2). https://doi.org/10.1007/s10994-024-06689-7

[Val2] Abudurexiti Y, Han G, Zhang F, et al (2025) An explainable unsupervised anomaly detection framework for industrial internet of things. Comput Secur 148. https://doi.org/10.1016/j.cose.2024.104130

[Val3] Aggarwal K, Sowmya K, Ramesh K (2025) DASTAD: Dual aspect self-supervised transformer-based anomaly detection in multivariate time-series. Arab J Sci Eng https://doi.org/10.1007/s13369-025-10300-z

[Val4] Alnegheimish S, He Z, Reimherr M, et al (2025) M^2AD: Multi-sensor multi-system anomaly detection through global scoring and calibrated thresholding. In: Int. Conf. Artif. Intell. Stat. (AISTATS'25), pp 4384–4392, URL https://proceedings.mlr.press/v258/alnegheimish25a.html

[Val5] Arshad S, Ha M, Park TH (2025) STAD: Self-supervised transformer for anomaly detection in multi-variate time series data. IEEE Access 13:178006–178020. https://doi.org/10.1109/ACCESS.2025.3616597

[Val6] Bashar MA, Nayak R (2025) ALGAN: Time series anomaly detection with adjusted-LSTM GAN. Int J Data Sci Anal 20(6):5719–5737. https://doi.org/10.1007/s41060-025-00810-2

[Val7] Belay MA, Rasheed A, Rossi PS (2025a) Autoregressive density estimation transformers for multivariate time series anomaly detection. In: IEEE Int. Conf. Acoust. Speech Signal Process. (ICASSP'25), pp 1–5, https://doi.org/10.1109/ICASSP49660.2025.10888728

[Val8] Belay MA, Rasheed A, Rossi PS (2025b) Sparse non-linear vector autoregressive networks for multivariate time series anomaly detection. IEEE Signal Process Lett

32:331–335. https://doi.org/10.1109/lsp.2024.3520019

[Val9] Boudjelli M, Cherrared S, Velloso PB, et al (2025) DREAM: Dual forecasting model for network anomaly detection. In: IEEE Netw. Oper. Manag. Symp. (NOMS'25), pp 1–7, https://doi.org/10.1109/NOMS57970.2025.11073605

[Val10] Canonico R, Lista F, Navarro A, et al (2025) Threat detection in reconfigurable cyber–physical systems through spatio-temporal anomaly detection using graph attention network. Comput Secur 156. https://doi.org/10.1016/j.cose.2025.104509

[Val11] Cao G, Wu Y, Yu D, et al (2025) Attack detection and location using state forecasting in multivariate time series of ics. IEEE Trans Netw Sci Eng 12(4):2989–3001. https://doi.org/10.1109/TNSE.2025.3555764

[Val12] Chen J, Feng M, Wirjanto TS (2025a) Prospective multi-graph cohesion for multivariate time series anomaly detection. In: Proc. ACM Int. Conf. Web Search Data Min. (WSDM'25), p 98–106, https://doi.org/10.1145/3701551.3703494

[Val13] Chen L, Gao X, Liu J, et al (2025b) A multivariate time series anomaly detection method with multi-grain dynamic receptive field. Knowl-Based Syst 309. https://doi.org/10.1016/j.knosys.2024.112768

[Val14] Chen T, Ren X, Lai J, et al (2025c) Toward transformer-compatible multivariate time series learning via visibility graph-based structural encoding. Knowl-Based Syst 329. https://doi.org/10.1016/j.knosys.2025.114389

[Val15] Chen T, Zheng B, Liu S, et al (2025d) Compatible unsupervised anomaly detection with multi-perspective spatio-temporal learning. In: IEEE Int. Conf. Data Eng. (ICDE'25), pp 4066–4078, https://doi.org/10.1109/icde65448.2025.00303

[Val16] Chen X, Huang X, Xiao R (2025e) LHR-STD: Learning heterogeneous representations through spatiotemporal decoupling. In: IEEE Int. Conf. Electron. Commun. Artif. Intell. (ICECAI'25), pp 703–707, https://doi.org/10.1109/ICECAI66283.2025.11170480

[Val17] Chen X, Li T, Ma Z, et al (2025f) CiTranGAN: Channel-independent based-anomaly detection for multivariate time series data. Electronics 14(9). https://doi.org/10.3390/electronics14091857

[Val18] Chen X, Zhu W, Zeng Z, et al (2025g) Anomaly detection model based on anomaly representation reinforcement and path iterative modeling. Concurr Comput: Pract Exp 37(21–22). https://doi.org/10.1002/cpe.70245

[Val19] Chen Z, Jiang J, Luo X, et al (2025h) Dual-channel hypergraph networks in the time–frequency domain for learning advanced spatiotemporal dependencies in multivariate time series. Neurocomputing 648. https://doi.org/10.1016/j.neucom.2025.130600

[Val20] Cheng Q, Balakrishnan K, Pan Z, et al (2025) Automated malfunction detection for robotic arms in panel manufacturing using deep latent state space model. SID Symp Dig Techn Pap 56(1):274–277. https://doi.org/10.1002/sdtp.18143

[Val21] Cho Y, Lee JH, Ham G, et al (2025) Generality-aware self-supervised transformer for multivariate time series anomaly detection. Appl Intell 55(7). https://doi.org/10.1007/s10489-025-06481-7

[Val22] Choi Y, Sohn K, Kim IJ (2025) Dual transformers with latent amplification for multivariate time series anomaly detection. IEEE Access 13:136433–136445. https://doi.org/10.1109/ACCESS.2025.3594473

[Val23] Cogranne R, Letourneau M, Doyen G (2025) A hybrid autoencoder–transformer model for detection of attacks on low latency services. In: IEEE Int. Conf. Adv. Mach. Learn. Data Sci. (AMLDS'25), pp 839–844, https://doi.org/10.1109/AMLDS63918.2025.11159464

[Val24] Colombi L, Vespa M, Belletti N, et al (2025) Embedding models for multivariate time series anomaly detection in industry 5.0. Data Sci Eng https://doi.org/10.1007/s41019-025-00295-w

[Val25] Cui K, Gao L, Deng X, et al (2025a) Multiview spatial–temporal interaction attention- based multivariate time series anomaly detection for distributed industrial control networks. IEEE Trans Netw pp 1–15. https://doi.org/10.1109/TON.2025.3614179

[Val26] Cui Z, Zang D, Zhang J, et al (2025b) MGCL: Multiorder graph neural network with cross-learning for multivariate time-series anomaly detection. IEEE Trans Instrum Meas 74:1–14. https://doi.org/10.1109/tim.2025.3577826

[Val27] Darban ZZ, Webb GI, Pan S, et al (2025a) CARLA: Self-supervised contrastive representation learning for time series anomaly detection. Pattern Recognit 157. https://doi.org/10.1016/j.patcog.2024.110874

[Val28] Darban ZZ, Yang Y, Webb GI, et al (2025b) DACAD: Domain adaptation contrastive learning for anomaly detection in multivariate time series. IEEE Trans Knowl Data Eng 37(8):4485–4496. https://doi.org/10.1109/tkde.2025.3569909

[Val29] Ding D, Wang Y, Tao H, et al (2025a) A dual-discriminator generative adversarial network for anomaly detection. IEEE Trans Neural Netw Learn Syst 36(10):19285–19296. https://doi.org/10.1109/TNNLS.2025.3585978

[Val30] Ding X, Wang J, Liu Y, et al (2025b) Multivariate time series anomaly detection using working memory connections in bi-directional long short-term memory autoencoder network. Appl Sci 15(5). https://doi.org/10.3390/app15052861

[Val31] Dong S, Sun S, Zhao P (2025) Deep learning with multi-attention for unsupervised industrial anomaly detection. In: IEEE Int. Conf. Artif. Intell. Electromech. Autom. (AIEA'25), pp 5–8, https://doi.org/10.1109/AIEA66061.2025.11159669

[Val32] Dou H, Shi P, Zhang Y, et al (2025) DeAnomaly: Anomaly detection for multivariate time series using robust decomposition and memory-augmented diffusion models. IEEE Trans Instrum Meas 74:1–14. https://doi.org/10.1109/tim.2025.3570337

[Val33] Du X, Zhou C, Tian YC, et al (2025) Data-augmented robust multivariate anomaly detection for industrial cyber-physical systems with incomplete features. Int J Mach Learn & Cyber 16(11):8661–8686. https://doi.org/10.1007/s13042-025-02700-2

[Val34] Fang X, Chen Y, Bhuiyan ZA, et al (2025) Mixer-transformer: Adaptive anomaly detection with multivariate time series. J Netw Comput Appl 241. https://doi.org/10.1016/j.jnca.2025.104216

[Val35] Feng C, Fan J, Jin G, et al (2025a) STE-RS: A novel framework for robust anomaly detection in uav flight data. Results Eng 27. https://doi.org/10.1016/j.rineng.2025.106801

[Val36] Feng C, Fan J, Liu Z, et al (2025b) Unmanned aerial vehicle anomaly detection based on causality-enhanced graph neural networks. Drones 9(6). https://doi.org/10.3390/drones9060408

[Val37] Feng Y, Niu Y (2025) Time series anomaly detection via reconstruction-limited probability estimation. In: Pattern Recognit. Artif. Intell. (ICPRAI'24), pp 447–461, https://doi.org/10.1007/978-981-97-8702-9_30

[Val38] Gao C, Ma H, Pei Q, et al (2025a) Dynamic graph-based graph attention network for anomaly detection in industrial multivariate time series data. Appl Intell 55(7). https://doi.org/10.1007/s10489-025-06412-6

[Val39] Gao H, Xin R, Chen P, et al (2025b) Memory-augment graph transformer based unsupervised detection model for identifying performance anomalies in highly-dynamic cloud environments. J Cloud Comp 14(1). https://doi.org/10.1186/s13677-025-00766-5

[Val40] Gao R, Wang J, Yu Y, et al (2025c) Enhanced graph diffusion learning with dynamic transformer for anomaly detection in multivariate time series. Neurocomputing 619. https://doi.org/10.1016/j.neucom.2024.129168

[Val41] Gao Y, Qi J, Ye H, et al (2025d) Variational graph attention networks with self-supervised learning for multivariate time series anomaly detection. IEEE Trans Instrum Meas 74:1–13. https://doi.org/10.1109/tim.2024.3502890

[Val42] Gao Y, Su R, Ben X, et al (2025e) EST transformer: enhanced spatiotemporal representation learning for time series anomaly detection. J Intell Inf Syst

63(3):783–805. https://doi.org/10.1007/s10844-025-00918-8

[Val43] Ge W, Congyue L, Shiwang X (2025) Multivariate time series anomaly detection in cyber security systems via stein discrepancy. In: IEEE Int. Wirel. Commun. Mob. Comput. Conf. (IWCMC'25), pp 961–966, https://doi.org/10.1109/IWCMC65282.2025.11059531

[Val44] Gu Y, Yan X, Qin H, et al (2025) HDTCNet: A hybrid-dimensional convolutional network for multivariate time series classification. Pattern Recognit 168. https://doi.org/10.1016/j.patcog.2025.111837

[Val45] Guan A, Zhu C, Kong L, et al (2025) Anomaly detection method for meteorological data based on neural networks. Russ Meteorol Hydrol 50(2):102–114. https://doi.org/10.3103/s1068373924600338

[Val46] Guo Q, Chen S, Jin D, et al (2025) Anomaly detection based on graph attention networks in semiconductor manufacturing processes. In: IEEE Int. Conf. Artif. Intell. Electromech. Autom. (AIEA'25), pp 32–37, https://doi.org/10.1109/AIEA66061.2025.11160592

[Val47] Ha TW, Kim MH (2025) Multivariate time series anomaly detection using directed hypergraph neural networks. Appl Artif Intell 39(1). https://doi.org/10.1080/08839514.2025.2538519

[Val48] Ham S, Jung H, Kim EY (2025) Enhancing multivariate time series anomaly detection with 2D spatial representations and channel attention. IEEE Signal Process Lett 32:4094–4098. https://doi.org/10.1109/LSP.2025.3619873

[Val49] Hammami W, Cherkaoui S, Wang S (2025) Enhancing network anomaly detection with quantum GANs and successive data injection for multivariate time series. In: IEEE Int. Wirel. Commun. Mob. Comput. Conf. (IWCMC'25), pp 1667–1672, https://doi.org/10.1109/iwcmc65282.2025.11059562

[Val50] Hao J, Chen P, Chen J, et al (2025) Effectively detecting and diagnosing distributed multivariate time series anomalies via unsupervised federated hypernetwork. Inf Process Manag 62(4). https://doi.org/10.1016/j.ipm.2025.104107

[Val51] He P, Tan X, Cheng Y (2025a) Boundary-aware adversarial ensemble learning for multivariate time series anomaly detection. Knowl-Based Syst 327. https://doi.org/10.1016/j.knosys.2025.114168

[Val52] He S, Guo Q, Li G, et al (2025b) Multivariate time series anomaly detection based on multiple spatiotemporal graph convolution. IEEE Trans Instrum Meas 74:1–14. https://doi.org/10.1109/tim.2024.3493890

[Val53] He S, Li G, Wang J, et al (2025c) Uni-directional graph structure learning-based multivariate time series anomaly detection with dynamic prior knowledge. Int J

Mach Learn & Cyber 16(1):267–283. https://doi.org/10.1007/s13042-024-02212-5

[Val54] He Y, Chen X, Miao D, et al (2025d) Graph-enhanced anomaly detection framework in multivariate time series using graph attention and enhanced generative adversarial networks. Expert Syst Appl 271. https://doi.org/10.1016/j.eswa.2025.126667

[Val55] Ho TKK, Armanfard N (2025) Contaminated multivariate time-series anomaly detection with spatio-temporal graph conditional diffusion models. In: Proc. Conf. Uncertain. Artif. Intell. (UAI'25), pp 1710–1729, URL https://proceedings.mlr.press/v286/ho25a.html

[Val56] Hoh M, Schaub H, Leuze N, et al (2025) Rethinking time series anomaly detection: A scalable transformer-based framework for large contexts. In: IEEE Int. Conf. Control Autom. Robot. (ICCAR'25), pp 295–302, https://doi.org/10.1109/ICCAR64901.2025.11072949

[Val57] Hossen K, Nur A, Habib MJA, et al (2025) Vision transformer masked autoencoders for unsupervised anomaly detection in time series. In: IEEE Int. Conf. Quantum Photon. Artif. Intell. Netw. (QPAIN'25), pp 1–6, https://doi.org/10.1109/QPAIN66474.2025.11171974

[Val58] Hu W, Xu J, Zhao X (2025) Multivariate time-series data anomaly detection via dimension independence and reconstruction. In: Proc. ACM Int. Conf. Data Storage Data Eng. (DSDE'25), p 15–22, https://doi.org/10.1145/3725472.3725475

[Val59] Huang X, Chen W, Hu B, et al (2025a) Graph mixture of experts and memory-augmented routers for multivariate time series anomaly detection. In: Proc. AAAI Conf. Artif. Intell. (AAAI'25), pp 17476–17484, https://doi.org/10.1609/aaai.v39i16.33921

[Val60] Huang X, Xiao R, Chen X (2025b) CKADformer: Enhanced transformer with causal convolution and kan for multivariate time series anomaly detection. In: IEEE Int. Conf. Electron. Commun. Artif. Intell. (ICECAI'25), pp 568–571, https://doi.org/10.1109/ICECAI66283.2025.11171201

[Val61] Huang Y, Liu P, Han R, et al (2025c) FreqWave-TranDuD: A multivariate time series anomaly detection method based on wavelet and fourier transforms. IEEE Access 13:68384–68397. https://doi.org/10.1109/access.2025.3557571

[Val62] Hussien Ali A, Almisbahi H, Alkayal E, et al (2025) Enhancing real-time anomaly detection of multivariate time series data via adversarial autoencoder and principal components analysis. Electronics 14(15). https://doi.org/10.3390/electronics14153141

[Val63] Jacob V, Diao Y (2025) Unsupervised anomaly detection in multivariate time series across heterogeneous domains. Proc VLDB Endow 18(6):1691–1704. https://doi.

org/10.14778/3725688.3725699

[Val64] Jang J, Kwon HY (2025) TAIL-MIL: time-aware and instance-learnable multiple instance learning for multivariate time series anomaly detection. In: Proc. AAAI Conf. Artif. Intell. (AAAI'25), pp 17582–17589, https://doi.org/10.1609/aaai.v39i17.33933

[Val65] Jeon SH, Kim K, Choi YS (2025) FEFM: Feature extraction and fusion module for enhanced time series anomaly detection. In: Proc. ACM/SIGAPP Symp. Appl. Comput. (SAC'25), p 1130–1137, https://doi.org/10.1145/3672608.3707794

[Val66] Jia X, Cao D, Zhuang N, et al (2025a) MultiverseAD: Enhancing spatial-temporal synchronous attention networks with causal knowledge for multivariate time series anomaly detection. Neural Netw 192. https://doi.org/10.1016/j.neunet.2025.107903

[Val67] Jia X, Peng W, Shen C, et al (2025b) Spatio-temporal mixed graph neural controlled differential equations with adaptive connection sampling for irregular multivariate time series anomaly detection. In: IEEE Int. Conf. Acoust. Speech Signal Process. (ICASSP'25), pp 1–5, https://doi.org/10.1109/ICASSP49660.2025.10888536

[Val68] Jia X, Qu J, Lyu Y, et al (2025c) A prediction-based anomaly detection method for traffic flow data with multi-domain feature extraction. Appl Sci 15(6). https://doi.org/10.3390/app15063234

[Val69] Jin Y, hua Gao Y, dong Lou W, et al (2025) AD-FGP: Industrial multivariate time-series anomaly detection via fusion of generative and predictive models. J Inf Sci Eng 41(1):155–171. https://doi.org/10.6688/JISE.202501_41(1).0009

[Val70] Kim M, Bhaumik KK, Ali AA, et al (2025) MIXAD: Memory-induced explainable time series anomaly detection. In: Pattern Recognit. (ICPR'24), p 242–257, https://doi.org/10.1007/978-3-031-78189-6_16

[Val71] Kong J, Wang K, Jiang M, et al (2025a) Gmad: multivariate time series anomaly detection based on graph matching learning. Int J Mach Learn & Cyber 16(5–6):3793–3808. https://doi.org/10.1007/s13042-024-02482-z

[Val72] Kong Y, Guo J, Ren L, et al (2025b) DADN: A dynamic anomaly detection network for multivariate time series data of the industrial internet of things. IEEE Trans Ind Informat 21(8):6294–6304. https://doi.org/10.1109/TII.2025.3563540

[Val73] Lan D, Zhang G, Guo R (2025) Diffusion graph model for time series anomaly detection via anomaly-aware graph sparsification and augmentation. In: Proc. ACM World Wide Web Conf. (WWW'25), p 2207–2214, https://doi.org/10.1145/3701716.3717376

[Val74] Li G, Ge M, Wan J, et al (2025a) MemMambaAD: Memory-augmented state space model for multivariate time series anomaly detection. Eng Appl Artif Intell 158. https://doi.org/10.1016/j.engappai.2025.111308

[Val75] Li G, Ge M, Zhou M, et al (2025b) Time series anomaly detection via temporal dependencies and multivariate correlations integrating. In: Neural Inf. Process. (ICONIP'24), pp 384–398

[Val76] Li J, Chen Y, Xing Y, et al (2025c) Contrast memory for unsupervised anomaly detection. In: IEEE Int. Conf. Acoust. Speech Signal Process. (ICASSP'25), pp 1–5, https://doi.org/10.1109/ICASSP49660.2025.10888471

[Val77] Li J, Chen Y, Xing Y, et al (2025d) HYMAN: Hybrid memory and attention network for unsupervised anomaly detection. In: IEEE Int. Conf. Acoust. Speech Signal Process. (ICASSP'25), pp 1–5, https://doi.org/10.1109/icassp49660.2025.10890028

[Val78] Li J, Yu Z, Jiang Q, et al (2025e) One-class classification constraint in reconstruction networks for multivariate time series anomaly detection. IEEE Trans Instrum Meas 74:1–13. https://doi.org/10.1109/TIM.2025.3548251

[Val79] Li K, Tang Z, Liang S, et al (2025f) MLAD: A multi-task learning framework for anomaly detection. Sensors 25(13). https://doi.org/10.3390/s25134115

[Val80] Li M, Liu K, Chen H, et al (2025g) TSINR: Capturing temporal continuity via implicit neural representations for time series anomaly detection. In: Proc. ACM SIGKDD Conf. Knowl. Discov. Data Min. V.1 (KDD'25), p 671–682, https://doi.org/10.1145/3690624.3709266

[Val81] Li Q, Zhang Z, Zhang Y, et al (2025h) JCCMTM: Joint channel-independent and channel-dependent strategy for masked multivariate time-series modeling. Neural Netw 192. https://doi.org/10.1016/j.neunet.2025.107922

[Val82] Li R, Liu Z, Zhu X, et al (2025i) Detecting multivariate time series anomalies with cascade decomposition consistency. IEEE Trans Instrum Meas 74:1–14. https://doi.org/10.1109/TIM.2025.3547479

[Val83] Li S, Wang Z, Wang X, et al (2025j) Frequency-enhanced and decomposed transformer for multivariate time series anomaly detection. Appl Intell 55(7). https://doi.org/10.1007/s10489-025-06441-1

[Val84] Li Y, Guo Y, Chen Y, et al (2025k) Self-supervised spatio-temporal representation learning for microservice anomaly detection. In: IEEE World Conf. Comput. Commun. Technol. (WCCCT'25), pp 278–284, https://doi.org/10.1109/WCCCT65447.2025.11027933

[Val85] Li Y, Wen Z, Chen Z, et al (2025l) Diffusion models with self-conditioning guidance for multivariate time series anomaly detection. Knowl-Based Syst 330. https://doi.

org/10.1016/j.knosys.2025.114511

[Val86] Li Y, Zhou Z, Sedlak B, et al (2025m) MGG-AD: Multi-granularity graph-based anomaly detection in iot systems. In: IEEE Int. Conf. Web Serv. (ICWS'25), pp 1–10, https://doi.org/10.1109/ICWS67624.2025.00096

[Val87] Li Z, Guo W, An J, et al (2025n) AD2T: Multivariate time-series anomaly detection with association discrepancy dual-decoder transformer. IEEE Sens J 25(7):11710–11721. https://doi.org/10.1109/jsen.2025.3543835

[Val88] Liang Q, Yin X (2025) Transformer-based contrastive learning with dynamic masking and adaptive pathways for time series anomaly detection. Expert Syst 42(8). https://doi.org/10.1111/exsy.70102

[Val89] Liang S, Guo Y, Chen Y, et al (2025) HiGraph: Learning hierarchical graph for multivariate time series anomaly detection in microservice systems. In: IEEE World Conf. Comput. Commun. Technol. (WCCCT'25), pp 302–308, https://doi.org/10.1109/wccct65447.2025.11028023

[Val90] Liu B, Tao L, Chen X, et al (2025a) VDDFormer: A Variable Dependency Discrepancy-Based Transformer for Multivariate Time Series Anomaly Detection . IEEE Trans on Big Data pp 1–14. https://doi.org/10.1109/TBDATA.2025.3600004

[Val91] Liu C, He S, Li S, et al (2025b) Detecting both seen and unseen anomalies in time series. ACM Trans Knowl Discov Data 19(4). https://doi.org/10.1145/3717071

[Val92] Liu H, Qiu X, Shi Y, et al (2025c) USD: Unsupervised soft contrastive learning for fault detection in multivariate time series. In: IEEE Int. Conf. Acoust. Speech Signal Process. (ICASSP'25), pp 1–5, https://doi.org/10.1109/ICASSP49660.2025.10890487

[Val93] Liu H, Zhang Z, Xi L, et al (2025d) Multivariate time series anomaly detection with hierarchical component-aware. IEEE Internet of Things J 12(22):48587–48596. https://doi.org/10.1109/JIOT.2025.3605933

[Val94] Liu J, Li Q, An S, et al (2025e) EdgeConvFormer: An unsupervised anomaly detection method for multivariate time series. In: Pattern Recognit. (ICPR'24), p 367–382, https://doi.org/10.1007/978-3-031-78128-5_24

[Val95] Liu S, Chen J, Liu Z, et al (2025f) Graph embedded patch-sense autoencoder with prior knowledge for multi-component system anomaly detection. Reliab Eng Syst Saf 256. https://doi.org/10.1016/j.ress.2024.110784

[Val96] Liu W, Liu C, Niu X, et al (2025g) Time series anomaly detection based on asymmetric autoencoder and gaussian mixture model. In: IEEE Int. Conf. Comput. Inf. Sci. Appl. Technol. (CISAT'25), pp 10–15, https://doi.org/10.1109/CISAT66811.2025.11181795

[Val97] Liu Y, Wang W, Wu Y (2025h) TiTAD: Time-invariant transformer for multivariate time series anomaly detection. Electronics 14(7). https://doi.org/10.3390/electronics14071401

[Val98] Liu Z, Gao M, Jiao P (2025i) GCAD: Anomaly detection in multivariate time series from the perspective of granger causality. In: Proc. AAAI Conf. Artif. Intell. (AAAI'25), pp 19041–19049, https://doi.org/10.1609/aaai.v39i18.34096

[Val99] Liu Z, Yang Z, Zheng X, et al (2025j) Denoising-enhanced dynamic graph modeling for anomaly detection in multivariate time series. In: IEEE Int. Symp. Adv. Electr., Electron. Comput. Eng. (ISAEECE'25), pp 652–657, https://doi.org/10.1109/ISAEECE66033.2025.11159890

[Val100] Long W, Yang B, Zhang Y, et al (2025) Dynamic anomaly detection in industrial robot clusters: A statistical-deep learning hybrid approach. Mech Syst Signal Process 234. https://doi.org/10.1016/j.ymssp.2025.112863

[Val101] Lu Z (2025) A robust anomaly detection approach for iiot time series. In: Proc. ACM Int. Conf. Front. Intell. Manuf. Autom. (CFIMA'24), p 168–173, https://doi.org/10.1145/3704558.3707091

[Val102] Luo Q, Dong J (2025) Time series anomaly detection model based on memory-enhanced transformer and graph network joint training. In: Proc. ACM Int. Conf. Comput. Model. Simul. Data Anal. (CMSDA'24), p 357–363, https://doi.org/10.1145/3727993.3728054

[Val103] Luo Y, Chen J, Qin S, et al (2025) Dual graph learning for multivariate time series anomaly detection in iout. IEEE Trans Netw Sci Eng p 1–16. https://doi.org/10.1109/tnse.2025.3598425

[Val104] Ma S, Zheng H, Guan S, et al (2025a) ST-MambaAD: Spatial-temporal mamba for multivariate time series anomaly detection. In: IEEE Interregional NEWCAS Conf. (NEWCAS'25), p 1–4, https://doi.org/10.1109/newcas64648.2025.11107158

[Val105] Ma Y, Liu W, Xu C, et al (2025b) Multivariate time series anomaly detection based on inverted transformer with multivariate memory gate. Entropy 27(9). https://doi.org/10.3390/e27090939

[Val106] Ma Y, Tao X, Wang H, et al (2025c) Anomaly detection model for edge network infrastructure based on time series. In: Adv. Intell. Comput. Technol. Appl. (ICIC'25), p 370–381, https://doi.org/10.1007/978-981-96-9884-4_31

[Val107] Ma Y, Wang H, Guan H, et al (2025d) Contrastive learning for robust time series anomaly detection in cyber-physical systems. In: Adv. Intell. Comput. Technol. Appl. (ICIC'25), p 343–354, https://doi.org/10.1007/978-981-96-9849-3_29

[Val108] Meng D, Zhou X, Lan S, et al (2025) MRGNN: Mamba-register-based graph neural network for unsupervised anomaly detection in multivariate time series. In: Adv. Intell. Comput. Technol. Appl. (ICIC'25), p 511–522, https://doi.org/10.1007/978-981-96-9894-3_42

[Val109] Müller M, Ernis G, Mock M (2025) Anomaly detection in multivariate time series using uncertainty estimation. In: Informed Machine Learning. Cognitive Technologies, Cognitive Technologies, pp 313–229, https://doi.org/10.1007/978-3-031-83097-6_14

[Val110] Nimbalkar A (2025) Anomnet: a hybrid framework for multivariate time series anomaly detection using attention-augmented state space models. In: IEEE Int. Conf. Comput. Technol. & Data Commun. (ICCTDC'25), pp 1–6, https://doi.org/10.1109/ICCTDC64446.2025.11158106

[Val111] Pan C, Su L, Xiong L, et al (2025) CT-DDPM: Anomaly detection of multivariate time series with copula and transformer-based denoising diffusion probabilistic models. Inf Sci 717. https://doi.org/10.1016/j.ins.2025.122279

[Val112] Qian C, Tang W, Wang Y (2025) RGAnomaly: Data reconstruction-based generative adversarial networks for multivariate time series anomaly detection in the internet of things. Future Gener Comput Syst 167. https://doi.org/10.1016/j.future.2025.107751

[Val113] Qin S, Zhu J, Guo A, et al (2025) MambaAD: Multivariate time series anomaly detection in iot via multi-view mamba. Neurocomputing 655. https://doi.org/10.1016/j.neucom.2025.131385

[Val114] Rasmussen TE, Algán FEC, Baum A (2025) Anomaly detection in broadband networks: Using normalizing flows for multivariate time series. Signal Process 230. https://doi.org/10.1016/j.sigpro.2024.109874

[Val115] Raza MA, Wardat M, Liu A (2025) DeepTrAnS: Mixer-based unsupervised time series anomaly detection for servers. In: IEEE Intell. Cybersecur. Conf. (ICSC'25), pp 91–98, https://doi.org/10.1109/ICSC65596.2025.11139978

[Val116] Rezakhani M, Seyfi T, Afghah F (2025) A transfer learning framework for anomaly detection in multivariate iot traffic data. In: IEEE Int. Conf. Commun. (ICC'25), pp 4975–4980, https://doi.org/10.1109/ICC52391.2025.11161334

[Val117] Rong H, Wu Y, Pei H, et al (2025) Spatial and temporal correlation aware network for anomaly detection in multivariate time series. In: Proc. ACM Asia-Pac. Artif. Intell. Big Data Forum (AIBDF'24), p 738–743, https://doi.org/10.1145/3718491.3718611

[Val118] Roy P, Boker A, Mili L (2025) Beyond marginals: Learning joint spatio-temporal patterns for multivariate anomaly detection. Trans Mach Learn Res URL https:

//openreview.net/forum?id=iETTv1okjX

[Val119] Schuster J, Wölfel A, Brunner F, et al (2025) PredTrAD – prediction-based transformer for anomaly detection in multivariate time series data. In: Interspeech 2025, p 3873–3877, https://doi.org/10.21437/interspeech.2025-501

[Val120] Shen KY (2025) Learn hybrid prototypes for multivariate time series anomaly detection. In: Int. Conf. Learn. Represent. (ICLR'25), URL https://openreview.net/forum?id=8TBGdH3t6a

[Val121] Sheng H, Peng X, Koh VKZ, et al (2025) TWavefussion: Wavelet-based diffusion with transformer for multivariate time series anomaly detection. In: IEEE Int. Symp. Circuits Syst. (ISCAS'25), pp 1–5, https://doi.org/10.1109/ISCAS56072.2025.11043617

[Val122] Shimillas C, Malialis K, Fokianos K, et al (2025) Transformer-based multivariate time series anomaly localization. In: IEEE Symp. Comput. Intell. Eng. Cyber-Phys. Syst. (CIES'25), pp 1–8, https://doi.org/10.1109/CIES64955.2025.11007637

[Val123] Song Y, Liu Y, Shu S (2025) Dynamic soft contrastive learning for time series anomaly detection. In: IEEE Int. Conf. Acoust. Speech Signal Process. (ICASSP'25), pp 1–5, https://doi.org/10.1109/ICASSP49660.2025.10889377

[Val124] Sun S, Liu X, Han L, et al (2025a) SAE-GAN: integrating stacked attention autoencoder and generative adversarial networks for multivariate time series anomaly detection. Appl Intell 55(16). https://doi.org/10.1007/s10489-025-06927-y

[Val125] Sun S, Zhou Y, Yao S, et al (2025b) Enhancing unsupervised anomaly detection in multivariate time series with variational autoencoders and multiresolution LSTM. In: Adv. Data Min. Appl. (ADMA'24), p 372–385, https://doi.org/10.1007/978-981-96-0840-9_26

[Val126] Tan Z, He S, Zhan H, et al (2025) Graphormer-based bayesian network conditional normalizing flow for multivariate time series anomaly detection in communication networks. In: IEEE Wirel. Commun. Netw. Conf. (WCNC'25), pp 1–6, https://doi.org/10.1109/WCNC61545.2025.10978548

[Val127] Tang Q, Dai C, Wu Y, et al (2025) MLP-Mixer based masked autoencoders are effective, explainable and robust for time series anomaly detection. Proc VLDB Endow 18(3):798–811. https://doi.org/10.14778/3712221.3712243

[Val128] Tian H, Kong H, Lu S, et al (2025a) Unsupervised anomaly detection of multivariate time series based on multi-standard fusion. Neurocomputing 611. https://doi.org/10.1016/j.neucom.2024.128634

[Val129] Tian J, Li M, Fang L, et al (2025b) SSDCL: Semi-supervised denoising-aware contrastive learning for time series anomaly detection in cyber-physical systems.

IEEE Trans Inf Forensics Secur 20:7302–7316. https://doi.org/10.1109/TIFS.2025.3588674

[Val130] Trappolini G, Purificato A, Siciliano F, et al (2025) Quantized auto encoder-based anomaly detection for multivariate time series data in 5g networks. IEEE Access 13:82668–82679. https://doi.org/10.1109/ACCESS.2025.3568133

[Val131] Villaboni D, Bazzani F, Castellini A, et al (2025) Transformer-based anomaly detection for mobile robots. In: IEEE Eur. Conf. Mob. Robots (ECMR'25), p 1–6, https://doi.org/10.1109/ecmr65884.2025.11163081

[Val132] Wang A, Zhang Q, Zhu M, et al (2025a) A novel spatio-temporal reconstruction approach for multivariate time series anomaly detection in heavy industry equipment monitoring. In: Proc. ACM Asia-Pac. Artif. Intell. Big Data Forum (AIBDF'24), p 761–766, https://doi.org/10.1145/3718491.3718615

[Val133] Wang C, Shi H, Hu J, et al (2025b) Pre-training enhanced transformer for multivariate time series anomaly detection. Inf Fusion 121. https://doi.org/10.1016/j.inffus.2025.103171

[Val134] Wang C, Wang Z, Dong H, et al (2025c) Fusionformer: A novel adversarial transformer utilizing fusion attention for multivariate anomaly detection. IEEE Trans Neural Netw Learn Syst 36(8):14479–14492. https://doi.org/10.1109/tnnls.2025.3542719

[Val135] Wang H, Zhang H (2025) An anomaly detection method for multivariate time series data based on variational autoencoders and association discrepancy. Mathematics 13(7). https://doi.org/10.3390/math13071209

[Val136] Wang H, Li J, Chen Y, et al (2025d) DifNet: Difference-based multi-resolution decomposition for time series anomaly detection. Appl Intell 55(7). https://doi.org/10.1007/s10489-025-06551-w

[Val137] Wang H, Liu Y, Yin H, et al (2025e) Res2coder: A two-stage residual autoencoder for unsupervised time series anomaly detection. Appl Intell 55(11). https://doi.org/10.1007/s10489-025-06684-y

[Val138] Wang H, Zhang W, Yang J, et al (2025f) Robust anomaly detection via neighborhood-adversarial signal-noise disentanglement. In: Proc. ACM Int. Conf. Intell. Syst. Commun. Comput. Netw. (ISCCN'25), p 181–184, https://doi.org/10.1145/3732945.3732972

[Val139] Wang J (2025) Enhancing anomaly detection in multivariate time series with hybrid deep learning architecture. In: IEEE Int. Conf. Neural Netw. Inf. Commun. Eng. (NNICE'25), pp 1040–1045, https://doi.org/10.1109/NNICE64954.2025.11064389

[Val140] Wang K, Kong J, Zhang M, et al (2025g) MAD-DGTD: Multivariate time series anomaly detection based on dynamic graph structure learning with time delay. Neurocomputing 635. https://doi.org/10.1016/j.neucom.2025.129887

[Val141] Wang L, Li C (2025) Adjacent neighborhood transformer-based diffusion model for anomaly detection under incomplete industrial data sources. In: Proc. ACM Int. Conf. Web Search Data Min. (WSDM'25), pp 577–585, https://doi.org/10.1145/3701551.3703565

[Val142] Wang L, Zhou Y, Ke W, et al (2025h) Harmful data enhanced anomaly detection for quasi-periodic multivariate time series. Appl Intell 55(7). https://doi.org/10.1007/s10489-025-06461-x

[Val143] Wang M, Wang H, Cao Z, et al (2025i) Large language models can be few-shot server anomaly detector. In: IEEE Int. Conf. Mach. Learn. Intell. Syst. Eng. (MLISE'25), p 280–284, https://doi.org/10.1109/mlise66443.2025.11100205

[Val144] Wang Q, Zhu Y, Sun Z, et al (2025j) A multi-scale patch mixer network for time series anomaly detection. Eng Appl Artif Intell 140. https://doi.org/10.1016/j.engappai.2024.109687

[Val145] Wang Q, Zhu Y, Sun Z, et al (2025k) Self-attention-based graph transformation learning for anomaly detection in multivariate time series. Complex Intell Syst 11(5). https://doi.org/10.1007/s40747-025-01839-3

[Val146] Wang T, Wu D, Wang J, et al (2025l) Learning in two-scales through LSTM-GPT2 fusion network: A hybrid approach for time series anomaly detection. Sensors 25(6). https://doi.org/10.3390/s25061849

[Val147] Wang T, Zou C, Liu Y, et al (2025m) TGM: An industrial sensor network anomaly detection. In: Adv. Intell. Comput. Technol. Appl. (ICIC'25), pp 395–407

[Val148] Wang X, Xu Q, Xu K, et al (2025n) Large pretrained foundation model for key performance indicator multivariate time series anomaly detection. IEEE Open J Comput Soc 6:177–188. https://doi.org/10.1109/ojcs.2024.3521217

[Val149] Wang Y, Cheng H, Xiong J, et al (2025o) Noise-resilient point-wise anomaly detection in time series using weak segment labels. In: Proc. ACM SIGKDD Conf. Knowl. Discov. Data Min. V.1 (KDD'25), p 1551–1562, https://doi.org/10.1145/3690624.3709257

[Val150] Wei C, Yuan J, Zhang Y, et al (2025a) Ranking neighborhood and class prototype contrastive learning for time series. IEEE Trans Big Data 11(4):1907–1917. https://doi.org/10.1109/tbdata.2024.3495509

[Val151] Wei X, Liu Q, Pan Z (2025b) Frequency-aware variational autoencoder with reinforcement learning for borehole strain anomaly detection. Earth Sci Inform 18(4).

https://doi.org/10.1007/s12145-025-02010-9

[Val152] Wen M, Chen Z, Xiong Y, et al (2025) LGAT: A novel model for multivariate time series anomaly detection with improved anomaly transformer and learning graph structures. Neurocomputing 617. https://doi.org/10.1016/j.neucom.2024.129024

[Val153] Wu X, Qiu X, Li Z, et al (2025a) CATCH: Channel-aware multivariate time series anomaly detection via frequency patching. In: Int. Conf. Learn. Represent. (ICLR'25), URL https://openreview.net/forum?id=m08aK3xxdJ

[Val154] Wu Y, Li Z, Chen J, et al (2025b) Multi-scale graph-level anomaly detection of complex equipment via a subgraph augmented contrastive self-supervised network. Meas Sci Technol 36(9). https://doi.org/10.1088/1361-6501/ae03df

[Val155] Wu Z, Zhu L, Yin Z, et al (2025c) MAFCD: Multi-level and adaptive conditional diffusion model for anomaly detection. Inf Fusion 118. https://doi.org/10.1016/j.inffus.2025.102965

[Val156] Xi Q, Li X, Chen P, et al (2025) Parallel heterogeneous graph learning based internet of things multivariate time series anomaly detection and explanation via cross-channel feature fusion. J Supercomput 81(13). https://doi.org/10.1007/s11227-025-07717-6

[Val157] Xia S, Rajasegarar S, Pan L, et al (2025) ConDGAD: Multi-augmentation contrastive learning for dynamic graph anomaly detection. In: Pattern Recognit. (ICPR'24), p 416–431, https://doi.org/10.1007/978-3-031-78389-0_28

[Val158] Xiao BW, Xing HJ, Li CG (2025) MulGad: Multi-granularity contrastive learning for multivariate time series anomaly detection. Inf Fusion 119. https://doi.org/10.1016/j.inffus.2025.103008

[Val159] Xiao T, Zeng F (2025) AnomalyTK: A multivariate time series anomaly detection method. In: IEEE Int. Conf. Sensor-Cloud Edge Comput. Syst. (SCECS'25), p 360–366, https://doi.org/10.1109/scecs65243.2025.11065321

[Val160] Xie X, Zheng W, Xiong S, et al (2025a) MTAD-Kanformer: multivariate time-series anomaly detection via kan and transformer. Applied Intell 55(11). https://doi.org/10.1007/s10489-025-06650-8

[Val161] Xie Y, Deng L (2025) Adkanet: Multivariate time series anomaly detection with kolmogorov-arnold network and transformer. In: Proc. ACM Int. Conf. Comput. Inf. Big Data Appl. (CIBDA'25), p 239–243, https://doi.org/10.1145/3746709.3746752

[Val162] Xie Y, Zhang H, Babar MA (2025b) Multivariate time series anomaly detection by capturing coarse-grained intra- and inter-variate dependencies. In: Proc. ACM World Wide Web Conf. (WWW'25), p 697–705, https://doi.org/10.1145/3696410.3714941

[Val163] Xing Y, Tan J, Zhang R, et al (2025) Robust anomaly detection of multivariate time series data via adversarial graph attention BiGRU. Big Data Cogn Comput 9(5). https://doi.org/10.3390/bdcc9050122

[Val164] Xu L, Wang B, Zhao D, et al (2025a) DAN: Neural network based on dual attention for anomaly detection in ics. Expert Syst Appl 263. https://doi.org/10.1016/j.eswa.2024.125766

[Val165] Xu Q, Ma D, Zhao H, et al (2025b) An online anomaly monitoring method based on multiscale spatiotemporal graph learning for wind turbine. IEEE Trans Ind Informat 21(11):8750–8758. https://doi.org/10.1109/TII.2025.3586066

[Val166] Xu Y, Li H, Xiong Z, et al (2025c) Multivariate time series anomaly detection based on device-edge-cloud collaboration in internet of things. In: 6GN Future Wirel. Netw. (6GN'24), pp 98–110

[Val167] Xue B, Gao X, Lu H, et al (2025) A dual-reconstruction self-rectification framework with momentum memory-augmented network for multivariate time series anomaly detection. Appl Soft Comput 182. https://doi.org/10.1016/j.asoc.2025.113558

[Val168] Yan AY, Speed TJ, Taylor CO (2025a) Relapse prediction using wearable data through convolutional autoencoders and clustering for patients with psychotic disorders. Sci Rep 15(1). https://doi.org/10.1038/s41598-025-03856-1

[Val169] Yan L, Hu H, Yang K, et al (2025b) Variational autoencoder based automatic clustering for multivariate time series anomaly detection. In: Wirel. Artif. Intell. Comput. Syst. Appl. (WASA'24), pp 151–162, https://doi.org/10.1007/978-3-031-71470-2_13

[Val170] Yang W, Chu W, Wu X, et al (2025) Industrial multivariate time-series data anomaly detection incorporating attention mechanisms and adversarial training. Int J Comput Integr Manuf p 1–19. https://doi.org/10.1080/0951192x.2025.2452985

[Val171] Yao M, Tao D, Qi P, et al (2025) Scalable large model for unlabeled anomaly detection with trio-attention u-transformer and manifold-learning siamese discriminator. IEEE Trans Serv Comput 18(2):1012–1025. https://doi.org/10.1109/tsc.2025.3536306

[Val172] Yao Y, Yang ZX (2025) DDConv: Disentangled dual branch convolutional network for anomaly detection in server machines. IEEE Internet of Things J 12(18):37327–37338. https://doi.org/10.1109/JIOT.2025.3583424

[Val173] Yu J, Gao X, Wang T, et al (2025a) A feature matching-based method for few-shot multivariate time series anomaly detection with symmetric patch mask siam transformer. Eng Appl Artif Intell 154. https://doi.org/10.1016/j.engappai.2025.110894

[Val174] Yu X, Zhang K, Liu Y, et al (2025b) Adversarial transformer-based anomaly detection for multivariate time series. IEEE Trans Ind Informat 21(3):2471–2480. https://doi.org/10.1109/tii.2024.3507211

[Val175] Yu YC, Ouyang YC, Lin CA (2025c) CBMAD: Anomaly detection in iot network traffic via consistent bidirectional mamba autoencoder. In: IEEE Int. Conf. High Perform. Switch. Routing (HPSR'25), pp 1–6, https://doi.org/10.1109/HPSR64165.2025.11038914

[Val176] Yu YC, Ouyang YC, Lin CA (2025d) PGTAD: Real-time and lightweight multivariate time-series anomaly detection for iot using patch gate GRU autoencoder. IEEE Access 13:168654–168675. https://doi.org/10.1109/ACCESS.2025.3610684

[Val177] Yu YC, Ouyang YC, Lin CA (2025e) TriP-LLM: A tri-branch patch-wise large language model framework for time-series anomaly detection. IEEE Access 13:168643–168653. https://doi.org/10.1109/ACCESS.2025.3613663

[Val178] Zeng Z, Wang R, Qiu H, et al (2025) A correlation-aware diffusion model for multivariate time series anomaly detection with missing values. In: IEEE Int. Conf. Comput. Support. Coop. Work Des. (CSCWD'25), pp 813–818, https://doi.org/10.1109/CSCWD64889.2025.11033566

[Val179] Zhan Y, Yang B, Ma Y (2025) Anomaly detection for small hydropower based on deep spatio-temporal modeling. In: IEEE Int. Conf. Mechatron. Technol. Intell. Manuf. (ICMTIM'25), pp 624–630, https://doi.org/10.1109/ICMTIM65484.2025.11040954

[Val180] Zhang A, Chen P, Gu Y, et al (2025a) Dynamic graph contrastive learning for multivariate time series anomaly detection. J Supercomput 81(8). https://doi.org/10.1007/s11227-025-07455-9

[Val181] Zhang H, Pang H, Zhao Y, et al (2025b) Spatio-temporal weighted graph reason learning for multivariate time-series anomaly detection. IEEE Internet of Things J 12(15):29373–29383. https://doi.org/10.1109/JIOT.2025.3569316

[Val182] Zhang J, Wang X, Yang Y, et al (2025c) A novel anomaly detection method for multivariate time series based on spatial-temporal graph learning. J King Saud Univ Comput Inf Sci 37(1–2). https://doi.org/10.1007/s44443-025-00024-3

[Val183] Zhang W, Luo C (2025) Decomposition-based multi-scale transformer framework for time series anomaly detection. Neural Netw 187. https://doi.org/10.1016/j.neunet.2025.107399

[Val184] Zhang W, He P, Wang S, et al (2025d) A hybrid spiking model for anomaly detection in multivariate time series. Expert Syst 42(8). https://doi.org/10.1111/exsy.70086

[Val185] Zhang W, Li X, Li J, et al (2025e) A time–frequency contrastive learning model for anomaly detection in multivariate time series. Complex Intell Syst 11(12). https://doi.org/10.1007/s40747-025-02119-w

[Val186] Zhang X, Wang G, Chen Y, et al (2025f) Inter-layer explainable variational autoencoder model for multivariate time series anomaly detection. Eng Appl Artif Intell 159. https://doi.org/10.1016/j.engappai.2025.111585

[Val187] Zhang Y, Gong C (2025) Anomaly detection representation learning framework towards mixed time series with scalable multivariate fusion. In: Adv. Data Min. Appl. (ADMA'24), p 256–268, https://doi.org/10.1007/978-981-96-0811-9_18

[Val188] Zhao M, Peng H, Li L (2025) Multivariate time-series anomaly detection based on dynamic graph neural networks and self-distillation in industrial internet of things. IEEE Internet of Things J 12(9):12181–12192. https://doi.org/10.1109/jiot.2024.3520362

[Val189] Zhu H, Xiao N, Ling H, et al (2025a) TSAD: Temporal–spatial association differences-based unsupervised anomaly detection for multivariate time-series. Neurocomputing 648. https://doi.org/10.1016/j.neucom.2025.130611

[Val190] Zhu K, Song P, Zhao C (2025b) Fuzzy state-driven cross-time spatial dependence learning for multivariate time-series anomaly detection. IEEE Trans Neural Netw Learn Syst 36(3):4532–4544. https://doi.org/10.1109/tnnls.2024.3371109