International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 07 Issue: 02 | February - 2023 Impact Factor: 7.185 ISSN: 2582-3930

A Literature Review of Air Quality Detection using Neural Networks

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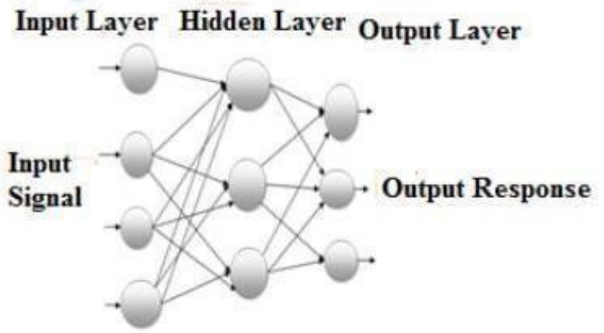
Abstract— ***The escalation of the social economy and urbanization, along with the rapid growth of industrialization, has worsened the issue of ambient air pollution. Air pollution has detrimental effects on public health in both developing and developed countries. Air quality predictors are necessary to control human activities in a particular geographical area and reduce pollution's harmful impacts. A new deep learning technique that combines neural networks can be used for detecting anomalies in air quality data. Numerous neural network models can be employed for air quality prediction. This review concentrates on earlier research works by various authors who have utilized neural networks in detecting air quality***

I. Introduction

Air pollution has become a significant issue in the current generation. Air pollution can cause severe respiratory problems in all living beings and has a wide range of effects on physical, economic, and biological systems. Any substance that exists in the atmosphere at a concentration that has the potential to harm living beings, plants, property, or the environment is considered an air pollutant, including noise. Indoor air pollutants can be generated by various household activities, such as cooking, burning biofuels, and heating, and can include chemicals released from detergents, household cleaners, aerosol sprays, wax, and paint. Outdoor air pollutants fall into two categories: primary and secondary air pollutants. Primary air pollutants are directly emitted



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Anomaly detection has gained significant popularity in recent years across various domains, such as fraud detection, intelligent transportation, and more. The goal of anomaly detection is to identify unusual data points and abnormal patterns that deviate significantly from typical performance patterns. By using anomaly detection, one can monitor early warnings, identify hotspots of anomalies, and determine the root causes of unusual occurrences.

In this study, the focus is on exploring the benefits of utilizing neural networks for predicting air pollution. The objective is to identify improved air quality predictors that can handle noisy and erroneous data while using a limited number of datasets.

Contribution

In this study, we aim to discuss the applications of neural networks in air quality detection and discuss some of the challenges of air pollution.

- We conducted a literature review on the use of neural networks for air quality detection in previous studies.
- We also analyzed the different proposed solutions inthose works and presented them in a simplified form.

Paper Organization

We have organized the remainder of this paper as follows. Section II is survey of literary works on the use Neural networks in Air Quality Detection.

II. Literature Survey

1. The article "Deep learning for anomaly detection: A review" by G. Pang, C. Shen, L. Cao, and A. Van Den Hengel was published in the March 2021 issue of ACM Computing Surveys.

Researchers across various disciplines have been actively studying anomaly detection, also known as novelty detection or outlier identification. However, unique complexities and challenges still require cutting-edge techniques. Deep anomaly detection, which is enabled by deep learning, has emerged as a critical research area in recent years. This study presents a comprehensive taxonomy of deep anomaly detection research, covering advances in three high-level categories and eleven fine-grained categories of approaches. The authors discuss the assumptions, objective functions, benefits, and drawbacks of these approaches before outlining their solutions to the aforementioned challenges. They also explore potential future prospects and novel approaches to addressing these issues

2. Article titled "Deep Learning-Based Intrusion Detection Systems" authored by J. Lansky and colleagues, published in IEEE Access in 2021.

The escalating complexity and seriousness of security threats on computer networks have led security researchers to employ different machine learning technologies to protect organizations' data and reputation. Recently, intrusion detection systems (IDS) have extensively adopted deep learning, which is one of the intriguing methodologies, to enhance their effectiveness in safeguarding computer networks and hosts. This article conducts a comprehensive survey and categorization of deep learning-based intrusion detection techniques with a focus on these approaches. It commences by providing an overview of the IDS architecture and several deep learning approaches, followed by categorizing these techniques based on the specific deep learning methods used.

3. Study by "Apeksha Aggarwal and Durga Toshniwal that focuses on detecting anomalous levels of nitrogen dioxide (NO2) and study was published in the Journal of the Air & Waste Management Association in 2019.

Detecting abnormal high concentrations of pollutants is a critical requirement for ensuring accurate future air quality forecasts. Although several statistical techniques have been proposed in the past to identify abnormal circumstances, many of these methods required expensive computations and were prone to false alarms. Therefore, this study proposes a combination of proximity- and clustering-based anomaly detection algorithms to identify anomalies in air quality data. Furthermore, the Gaussian distribution feature of the real-world dataset is utilized to distinguish abnormalities. The results demonstrate that our approach provides dual benefits of efficient anomaly detection and improved accuracy by reducing false alarms. Specifically, this work focuses on studying the presence of NO2 content in the air.

4. In September 2019, M. Cui, J. Wang, A. R. Florita, and Y. Zhang published a paper titled "Generalized graph Laplacian based anomaly detection for spatiotemporal micro-PMU data" in IEEE Transactions on Power Systems.

In this letter, the authors utilize the general graph Laplacian (GGL) matrix to demonstrate the spatiotemporal relationship of distribution-level phasor measurement unit (PMU) data. To achieve this, PMU data for a particular time range are segmented, and the GGL matrix is estimated through an optimization problem formulated using a Lagrangian function. The iterative process involves creating an optimal update in the form of a quadratic program problem. The normal diagonal elements of the GGL matrix are utilized as a quantitative metric to enable PMU-based spatiotemporal analysis. The effectiveness of the proposed approach is demonstrated using real-world PMU measurements obtained from test feeders in Riverside, California, USA

5. A survey" by Leman Akoglu, Hanghang Tong, and Danai Koutra is a comprehensive review of the methods used in graph-based anomaly detection and description. It was published in the journal Data Mining and Knowledge Discovery in 2015.

The identification of anomalies in data is crucial for various applications in fields such as security, finance, healthcare, and law enforcement. While numerous techniques for detecting outliers and anomalies in unstructured collections of multi-dimensional points have been developed over time, methods for structured graph data have gained prominence in recent years as graph data has become more prevalent. Given that objects in graphs have long-range relationships, a range of unique technologies have been developed to detect anomalies in graph data. This survey aims to provide a comprehensive, systematic, and organized overview of the most cutting-edge techniques for detecting anomalies in graph data. The authors have made a significant contribution by presenting a general framework for categorizing the algorithms based on different parameters

6. . This article, written by Kim, Lee, Shin, and Lim in 2022, discusses the current state and challenges of graph anomaly detection using graph neural networks.

Graphs are widely used to model complex systems, and detecting anomalies in graphs is a significant problem in the analysis of complex systems. An anomaly in a graph refers to a pattern that deviates from the expected patterns for its properties and/or structures. In recent years, graph neural networks (GNNs) have garnered significant attention due to their ability to efficiently learn graph representations through message passing and effectively perform challenging machine learning tasks such as node classification, link prediction, and graph classification. GNN-based solutions leverage knowledge of graph attributes and/or structures to accurately identify anomalies and tackle the graph anomaly detection challenge. This survey provides a comprehensive overview of the most recent developments in graph anomaly detection.

7. The article titled "Neural Network Models for Air Quality Prediction: A Comparative Study" authored by Barai, S.V., Dikshit, A.K., and Sharma S.

The paper aims to identify neural network-based predictors for air quality that are robust enough to handle noisy and erroneous data and can operate with a limited number of datasets. Various neural network model variations, including the Recurrent Network Model (RNM), Change Point Detection Model with RNM (CPDM), Sequential Network Construction Model (SNCM), and Self-Organizing Feature Maps (SOFM), are used for predicting air quality. The developed models are used to simulate and forecast air quality based on long-term (annual) and short-term (daily) data. Overall, the models demonstrated only moderate predictive performance for air quality trends. However, the SOFM model outperformed other models significantly in both long-term (year) and short-term (daily) data prediction.

8. The paper authored by Zhao, van Heeswijk, and Karhunen titled 'Air quality forecasting using neural networks' presents a study on the use of neural networks for air quality prediction.

This paper proposes a neural network approach to predict air quality using both external weather data and historical air quality data. The primary model for the predictions is a supervised version of the Extreme Learning Machine, with feature selection utilized to identify the most relevant inputs for the model. The suggested approach is evaluated using various methods for integrating spatial data. The results show that incorporating meteorological data improves accuracy, the handling of geographical data significantly impacts the model, and the model effectively selects appropriate inputs and produces reliable air quality forecasts.

9. The paper titled "Prediction of Indoor Air Quality Using Artificial Neural Networks" by Xie, H., Ma, F., and Bai, Q. presented a study on using artificial neural networks to predict indoor air quality.

This study aimed to predict indoor air quality using artificial neural networks. The ANNs were trained with six indoor air contaminants and three interior comfort factors as input variables, and the occupant symptom metric (PIAQ) was used as the outcome variable to indicate indoor air quality. Data collected from previous investigations that included information on comfort variables, PIAQ, and pollutant concentrations were used in the study. ANN modeling was carried out using a feed-forward network with a back-propagation method, a momentum term, and a variable learning rate. The study found that among the built-in networks, a two-hidden-layered network with a high correlation coefficient and a low root mean square error for the test set demonstrated the best prediction performance. Moreover, the built-in networks outperformed the multiple linear regression analyses.

10. The paper titled "Graph convolutional networks for traffic anomaly" by Y. Hu, A. Qu, and D. Work presents a new approach for detecting traffic anomalies using graph convolutional networks.

The authors formulated a novel approach to detect anomalies in directed weighted graphs that represent traffic conditions at different time intervals. They proposed the Context augmented Graph Autoencoder (Con-GAE), which combines graph embedding and context embedding techniques to capture spatial traffic network patterns and mitigate the challenges of high dimensionality and data sparsity. Con-GAE employs an autoencoder architecture and semi-supervised learning for anomaly detection. Their extensive experiments show that Con-GAE outperforms state-of-the-art baselines in detecting anomalies, improving the area under the curve (AUC) scores by 0.1-0.4 on real-world, large-scale OD matrix datasets.

11. The paper titled "AF2GNN: Graph convolution with adaptive filters and aggregator fusion for hyperspectral image classification" by Y. Ding et al. proposes a novel approach for hyperspectral image classification that utilizes graph convolutional neural networks.

The authors of this paper propose using a superpixel segment technique to improve the spatial properties of a hyperspectral image (HSI) and reduce the number of nodes in the graph. To transform the spectral properties of superpixels, a two-layer 1D CNN is employed. Additionally, the authors create a linear function that combines different graph filters to enable the adaptive selection of graph filters by training various weight matrices. Degree-scalers are also defined to integrate the filters and show the graph structure. Finally, the Adaptive Filters and Aggregator Fusion Graph Neural Network (AF2GNN) is presented, which implements the adaptive filters and aggregator fusion process within a single network.

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12. The authors of this study, Ding, Zhao, Zhang, Cai, Yang, and Zhan, propose a semi-supervised locality preserving dense graph neural network (LP-DGNN) with ARMA (AutoRegressive Moving Average) filters and context-aware learning for hyperspectral image classification.

The study presents the ARMA filter as a substitute for the spectral filter in GNNs, which provides better resistance to noise and an improved ability to capture overall graph structure. The authors also demonstrate how the ARMA filter can simplify calculations and propose a dense structure that preserves locality while incorporating the ARMA filter. A layer-wise context-aware learning mechanism is presented to extract local knowledge from each layer of the dense ARMA network. The experimental results on three HSI datasets show that DARMA-CAL outperforms other state-of-the-art algorithms.

13. The authors of this paper, B. Zong, Q. Song, M. R. Min, W. Cheng, C. Lumezanu, D. Cho, and H. Chen, presented a novel approach for unsupervised anomaly detection called Deep Autoencoding Gaussian Mixture Model.

This paper presents the Deep Autoencoding Gaussian Mixture Model (DAGMM) as an unsupervised anomaly detection method. DAGMM utilizes a deep autoencoder to generate a low-dimensional representation and reconstruction error for each input data point, which are then fed into a Gaussian Mixture Model (GMM). Unlike the conventional Expectation-Maximization (EM) algorithm, the parameters of both the autoencoder and the mixture model are jointly optimized in an end-to-end manner using a separate estimation network. By balancing autoencoding reconstruction, density estimation of latent representation, and regularization, the joint optimization allows the autoencoder to avoid less desirable local optima and further reduce reconstruction errors. The proposed method eliminates the need for pre-training. Experimental results demonstrate the effectiveness of DAGMM for anomaly detection.

14. A long short-term memory (LSTM) based encoder-decoder architecture is proposed for detecting anomalies in data collected from multiple sensors, as presented in a research paper by P. Malhotra, A. Ramakrishnan, G. Anand, L. Vig, P. Agarwal.

The EncDec-AD technique proposed by the authors for anomaly detection utilizes Long Short Term Memory Networks and employs an encoder-decoder approach to learn the 'normal' behavior of time-series and detect anomalies using the reconstruction error. The authors conduct experiments using various datasets with both predictable and unpredictable behavior, including power demand, space shuttle, ECG, and two real-world engine datasets, as well as three publicly accessible semi-predictable time-series datasets. The results demonstrate the robustness of EncDec-AD in identifying anomalies in time-series with different patterns, including periodic, aperiodic, and quasi-periodic, and show that it is capable of detecting anomalies.

15. Deep dual support vector data description is used for anomaly detection on attributed networks in a recent study by Zhang et al. (2022).

The authors of this study propose a novel approach for anomaly detection on attributed networks called Dual-SVDAE. The model is an end-to-end Deep Dual Support Vector Data description based Autoencoder that takes both the network's structure and attributes into consideration. To learn the latent representation of nodes in the structure and attribute spaces, the model consists of a structure autoencoder and an attribute autoencoder. The two autoencoders are then subjected to a dual-hypersphere learning procedure to learn two hyperspheres of normal nodes from the perspectives of structure and attribute, respectively. Moreover, the authors combine the structure and attribute embeddings to construct the node attribute for joint learning. Aberrant nodes can be identified based on their distance from the learned centers of each hypersphere in the latent structure and attribute spaces. The proposed approach is extensively tested on actual attributed networks, and the results show that Dual-SVDAE outperforms state-of-the-art techniques, proving its effectiveness.

16. T.N. Kipf and M. Welling introduced a novel approach for semi-supervised classification using graph convolutional networks. The method is based on a graph-based representation of data and enables the classification of nodes in a graph with both labeled and unlabeled data.

The paper presents a scalable method for semi-supervised learning on graph-structured data that utilizes a convolutional neural network specifically designed for graphs. The authors use a localized first-order approximation of spectral graph convolutions to justify their convolutional design. The algorithm learns hidden layer representations that incorporate both local network structure and node attributes and scales linearly as the number of graph edges grows. The authors demonstrate the superiority of their technique over related methods through experiments on citation networks and a knowledge graph dataset.

17. The paper "NetWalk: A flexible deep embedding approach for anomaly detection in dynamic networks" by Yu et al. (2018) proposes a novel method for detecting anomalies in dynamic networks.

This article proposes NetWalk, a new method for detecting anomalies in dynamic networks. NetWalk uses clique embedding to encode the network vertices into vector representations, which can be computed efficiently using reservoir sampling. By minimizing the pairwise distance between the vertex representations of each walk in the dynamic network and the deep autoencoder reconstruction error, acting as global regularization, NetWalk learns network representations that can be updated as the network evolves. An incremental and dynamic anomaly detection method is then applied based on the learned low-dimensional vertex representations using clustering.

18. The authors of this paper, Harrou et al., describe a strategy for detecting anomalous ozone measurements using a deep learning-based approach. They published their findings in the IEEE Sensors Journal in September 2018.

This study presents an unsupervised method for anomaly detection in unlabeled ozone samples that utilizes a combination of one-class support vector machine and deep belief networks (DBNs) to capture the nonlinear changes in ground-level ozone concentrations and identify anomalous measurements. The effectiveness of the proposed technique is evaluated using data from Isère, France, and compared against other methods including DBN-based clustering and auto-encoders. Results indicate that the proposed method is capable of effectively detecting anomalies in ozone data.

19. In their 2020 study published in the Journal of Environmental Management, Wang et al. proposed a novel hybrid model for forecasting daily air quality index (AQI), which combines an outlier detection and correction algorithm with a heuristic intelligent optimization algorithm.

This study introduces a hybrid model that integrates heuristic intelligent optimization algorithms and outlier identification and correction algorithms to overcome the shortcomings of current methods. The model employs a widely used heuristic intelligent optimization algorithm to optimize the extreme learning machine parameters for each subseries and improve forecasting accuracy. The experimental results indicate that the hybrid model performs better than existing approaches and can effectively identify outliers, providing accurate predictions.

20. The study conducted by Ghazali and Ismail in 2012 aimed to predict air quality using artificial neural networks.

The primary objective of this study is to create a neural network model for air quality prediction. The study utilizes a feed-forward neural network algorithm, which considers various variables, including temperature, relative humidity, air velocity, sulphur dioxide (SO_2), carbon monoxide (CO), nitrogen dioxide (NO_2), and nitric oxide (NO).

21. Study published in 2022 by Wang et al. developed an air quality index prediction model that combines convolutional neural networks (CNNs) and improved long short-term memory (ILSTM) algorithms.

The study introduces a new model called CNN-ILSTM for predicting AQI (Air Quality Index). This model combines Convolutional Neural Networks (CNN) and an improved version of Long Short-Term Memory (LSTM) called ILSTM. ILSTM enhances the LSTM architecture by removing the output gate and improving the input and forget gates. Additionally, it includes a Conversion Information Module (CIM) to prevent supersaturation during the learning process. By utilizing ILSTM, the model achieves faster training times, higher prediction accuracy, and better utilization of previous data. The CNN component of the model effectively extracts the input data's eigenvalues, which improves the model's overall performance.

22. In their paper titled 'The Prediction of Quality of the Air Using Supervised Learning,' C.R.K et al. explore the use of supervised learning for predicting air quality.

The goal of the research is to develop machine learning methods that can accurately forecast air quality. To achieve this, the researchers will use a supervised machine learning technique (SMLT) to mine the dataset for information. This process will involve variable recognition, univariate, bivariate, and multivariate analysis, as well as missing value treatment and data cleaning. The results of this analysis will provide a framework for sensitivity analysis of the model parameters, allowing for measurement of accuracy in predicting air quality contamination. Ultimately, the researchers aim to create a machine learning-based approach that can accurately predict the Air Quality Index value by comparing different supervising classification machine learning algorithms and producing the most accurate prediction results.

23. A paper titled "Machine Learning Methods for Air Quality Monitoring" was presented by Mohamed Akram Zaytar and Chaker El Amrani.

Recent years have seen a rise in the adoption of machine learning techniques for environmental modelling, with a particular emphasis on time series forecasting and computer vision. This review provides a thorough and structured examination of the machine learning techniques currently employed to tackle air quality monitoring tasks, with a specific focus on air quality modelling using data from sensor devices and satellite imagery. Furthermore, the authors propose avenues for future research, specifically in the areas of representation learning and neural network modelling.

24. This study by Xayasouk and Lee, published in WIT Transactions on Ecology and the Environment in 2018, proposes an air pollution prediction system that utilizes deep learning techniques.

The authors of this study proposed a deep learning approach for forecasting air pollution levels in South Korea. They used the stacked autoencoder model to train the system with the available data. The results of the experiment demonstrate the effectiveness of the proposed model for predicting air pollution levels in the region.

25. The paper titled 'Machine learning approaches used for air quality forecast: A review' by Senthivel and Chidambaranathan in 2022 provides an overview of various machine learning techniques employed in air quality forecasting.

The primary aim of this work is to offer insights to researchers on the importance of various Machine Learning techniques for predicting the Air Quality Index. The study examines different approaches for predicting and categorizing AQI using machine learning techniques. Machine learning-based methods can be used to forecast the air quality index, and noteworthy techniques include logistic regression, decision trees, support vector classifiers, random forest trees, Naive Bayes classifiers, and K-nearest neighbor. The accuracy, recall, and F1 score of these techniques can vary when applied to Air Quality Index datasets. To highlight several algorithms that can be used for the stated objective, a comparison table is provided, along with their respective advantages.

III. Conclusion

. This survey shows that a deep learning approach can be used to detect anomalies in air quality data by considering the spatial correlation, temporal correlation, and multivariate features of the data. The approach combines temporal and spatial correlations, and uses the degree of node information correlation for feature fusion to represent spatiotemporal correlation in a graph structure. The method constructs spatiotemporal graph structure data to characterize changes in node information, and uses an advanced deep learning model called Con-GAE to detect abnormal air quality events. The effectiveness of the approach is demonstrated by testing it on synthetic test sets created from real-world datasets. Specifically, the approach establishes a weighted adjacency matrix to represent spatial correlation, constructs a feature matrix to represent temporal correlation, and transforms changes in node information into changes in edge weights to characterize spatiotemporal correlation in the graph structure data.

References

[1] [1] Y. Ding, Z. Zhang, X. Zhao, D. Hong, W. Li, W. Cai, and Y. Zhan, ``AF2GNN: Graph convolution with adaptive lters and aggregator fusion for hyperspectral image classication," Inf. Sci., vol. 602, pp. 201219 Jul. 2022.

[2] [2] Senthivel, S., Chidambaranathan, M. (2022). Machine learning approaches used for air quality forecast: A review. Revue d'Intelligence Artificielle, Vol. 36, No. 1, pp. 73-78. https://doi.org/10.18280/ria.360108.

[3] [3] Xayasouk, Thanongsak & LEE, HWAMIN. (2018). Air pollution prediction system using deep learning. WIT Transactions on Ecology and the Environment. 230. 71- 79. 10.2495/AIR180071.

[4] [4] Mohamed Akram Zaytar and Chaker El Amrani. 2020. Machine Learning Methods for Air Quality Monitoring. In Proceedings of the 3rd International Conference on Networking, Information Systems & Security (NISS2020). Association for Computing Machinery, New York, NY, USA, Article 16, 1–5. https://doi.org/10.1145/3386723.3387835

[5] [5] C. R. K, N. R. K, B. P. K and P. S. Rajendran, "The Prediction of Quality of the Air Using Supervised Learning," 2021 6th International Conference on Communication and Electronics Systems (ICCES), 2021, pp. 1-5, doi: 10.1109/ICCES51350.2021.9488983.

[6] [6] Wang, J., Li, X., Jin, L. et al. An air quality index prediction model based on CNN-ILSTM. Sci Rep 12, 8373 (2022). https://doi.org/10.1038/s41598-022- 12355-6

[7][7]

[8] [7] Ghazali, S., & Ismail, L.H. (2012). Air Quality Prediction Using Artificial Neural Network.

[9] [8] J. Z. Wang, P. Du, Y. Hao, X. Ma, T. Niu, and W. D. Yang, ''An innovative hybrid model based on outlier detection and correction algorithm and heuristic intelligent optimization algorithm for daily air quality index forecasting,'' J. Environ. Manage., vol. 255, Feb. 2020, Art. no. 109855.

[10] [9] F. Harrou, A. Dairi, Y. Sun, and F. Kadri, ''Detecting abnormal ozone measurements with a deep learning- based strategy,'' IEEE Sensors J., vol. 18, no. 17, pp. 7222–7232, Sep. 2018.

[11] [10]W. Yu, W. Cheng, C. C. Aggarwal, K. Zhang, H. Chen, and W. Wang,''NetWalk: A flexible deep embedding approach for anomaly detectionin dynamic networks,'' in Proc. 24th ACM SIGKDD Int. Conf. Knowl. Discovery Data Mining, Jul. 2018, pp. 2672–2681.

[12] [11]T.N. Kipf and M. Welling, ''Semi-supervised classification with graph convolutional networks,'' in Proc. 5th Int. Conf. Learn. Represent. (ICLR),2017, pp. 1–22.

[13] [12]F. Zhang, H. Fan, R. Wang, Z. Li, and T. Liang, ''Deep dual support vector data description for anomaly detection on attributed networks,'' Int.J. Intell. Syst., vol. 37, no. 2, pp. 1509–1528, Feb. 2022.

[14] [13] P. Malhotra, A. Ramakrishnan, G. Anand, L. Vig, P. Agarwal, and G. Shroff, ''LSTM-based encoder– decoder for multi-sensor anomaly detection,'' 2016, arXiv:1607.00148.

[15] [14]B. Zong, Q. Song, M. R. Min, W. Cheng, C. Lumezanu,

[16] D. Cho, and H. Chen, ''Deep autoencoding Gaussian mixture model for unsupervised anomaly detection,'' in Proc. 6th Int. Conf. Learn. Represent. (ICLR), 2018, pp. 1–18.

[17] [15] Y. Ding, X. Zhao, Z. Zhang, W. Cai, N. Yang, and Y. Zhan, ''Semi887 supervised locality preserving dense graph neural network with ARMA filters and context- aware learning for hyperspectral image classification,''IEEE Trans. Geosci. Remote Sens., vol. 60, pp. 1–12, 2022.

[18] [16] Y. Ding, Z. Zhang, X. Zhao, D. Hong, W. Li, W. Cai, and Y. Zhan,891 ''AF2GNN: Graph convolution with adaptive filters and aggregator fusion892

for hyperspectral image classification,'' Inf. Sci., vol. 602, pp.201–219,893 Jul. 2022.

[19] [17] G. Pang, C. Shen, L. Cao, and A. Van Den Hengel, ''Deep learning for anomaly detection: A review,'' ACM Comput. Surv., vol. 54, no. 2, pp. 1–38, Mar. 2021.

[20] [18]J. Lansky et al., "Deep Learning-Based Intrusion Detection Systems: A Systematic Review," in IEEE Access, vol. 9, pp. 101574-101599, 2021, doi: 10.1109/ACCESS.2021.3097247.

[21] [19]Apeksha Aggarwal & Durga Toshniwal (2019) Detection of anomalous nitrogen dioxide (NO2) concentration in urban air of India using proximity and clustering methods, Journal of the Air & Waste Management Association, 69:7, 805-822, DOI: 10.1080/10962247.2019.1577314.

[22] [20]M. Cui, J. Wang, A. R. Florita, and Y. Zhang, ''Generalized graph Laplacian based anomaly detection for spatiotemporal micro-PMU data,'' IEEE Trans. Power Syst., vol. 34, no. 5, pp. 3960–3963, Sep. 2019.

[23][23]

[24] [21] L. Akoglu, H. Tong, and D. Koutra, ''Graph based anomaly detection and description: A survey,'' Data Mining Knowl. Discovery, vol. 29, no. 3, pp. 626–688, 2015.

[25] [22]Kim, H., Lee, B.S., Shin, W., & Lim, S. (2022). Graph Anomaly Detection With Graph Neural Networks: Current Status and Challenges. IEEE Access, 10, 111820-111829.

[26] [23]Barai, S.V., Dikshit, A.K., Sharma, S. (2007). Neural Network Models for Air Quality Prediction: A Comparative Study. In: Saad, A., Dahal, K., Sarfraz, M., Roy, R. (eds) Soft Computing in Industrial Applications. Advances in Soft Computing, vol 39. Springer, Berlin, Heidelberg.

[27] [24]C. Zhao, M. van Heeswijk and J. Karhunen, "Air quality forecasting using neural networks," 2016 IEEE Symposium Series on Computational Intelligence (SSCI), 2016, pp. 1-7, doi: 10.1109/SSCI.2016.7850128.

[28] [25] Xie, H., Ma, F., & Bai, Q. (2009). Prediction of Indoor Air Quality Using Artificial Neural Networks. 2009 Fifth International Conference on Natural Computation, 2, 414-418.

[29] [26]Y. Hu, A. Qu, and D. Work, ''Graph convolutional networks for traffic anomaly,'' 2020,arXiv:2012.13637.

[30] [27]Aggarwal, C.C. (2017). An Introduction to Outlier Analysis. In: Outlier Analysis. Springer, Cham. https://doi.org/10.1007/978-3-319-47578-3_1.

[31] [28] Davide Abati, Angelo Porrello, Simone Calderara, Rita Cucchiara; Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR), 2019, pp. 481-490.

[32] [29] Angiulli, F., Pizzuti, C. (2002). Fast Outlier Detection in High Dimensional Spaces. In: Elomaa, T., Mannila, H., Toivonen, H. (eds) Principles of Data Mining and Knowledge Discovery. PKDD 2002. Lecture Notes in Computer Science, vol 2431. Springer, Berlin, Heidelberg. https://doi.org/10.1007/3-540-45681-3_2.

[33] [30] Varun Chandola, Arindam Banerjee, Vipin Kumar , Anomaly detection: A survey ACM Computing SurveysVolume 41Issue 3July 2009 Article No.: 15pp 1– 58 https://doi.org/10.1145/1541880.1541882.

[31] Akoglu, L., Tong, H. & Koutra, D. Graph based anomaly detection and description: a survey. Data Min Knowl Disc 29, 626–688 (2015). https://doi.org/10.1007/s10618-014-0365-y.