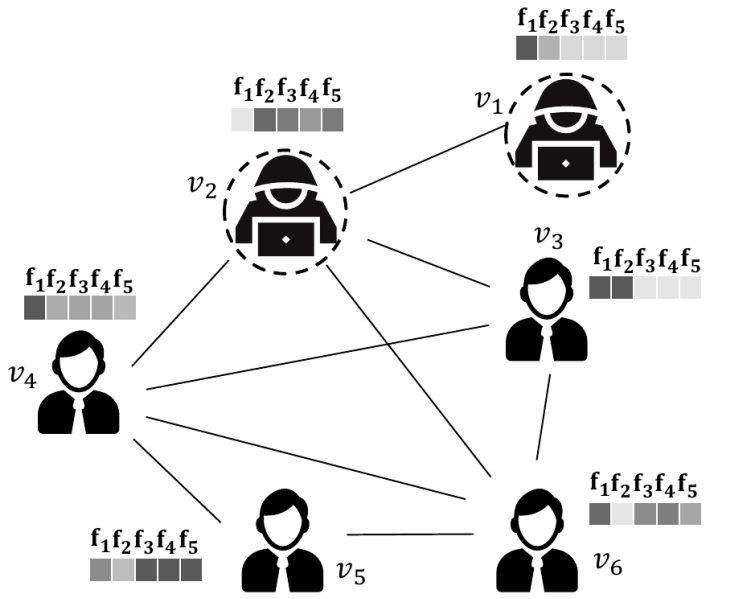
BOND: Benchmarking Unsupervised Outlier Node Detection on Static Attributed Graphs

Kay Liu[1,*], Yingtong Dou[1,8,*], Yue Zhao[2,*], Xueying Ding[2], Xiyang Hu[2], Ruitong Zhang[3], Kaize Ding[4], Canyu Chen[5], Hao Peng[3], Kai Shu[5], Lichao Sun[6], Jundong Li[7], George H. Chen[2], Zhihao Jia[2], Philip S. Yu[1]

[1]University of Illinois Chicago [2]Carnegie Mellon University [3]Beihang University
[4]Arizona State University [5]Illinois Institute of Technology [6]Lehigh University
[7]University of Virginia [8]Visa Research

NeurIPS 2022 Datasets and Benchmarks Track

Unsupervised Outlier Node Detection on Static Attributed Graphs



https://github.com/kaize0409/GCN_AnomalyDetection/raw/master/framework.png

Outlier detection on graphs has broad applications:

- Financial fraud detection on transaction networks
- Fake account detection on social networks
- Spam review detection on e-commerce websites

Limitation of existing works:

- Lack of a comprehensive benchmark
- Many algorithms only evaluated on synthetic outliers
- Limited analyses of efficiency in both time and space

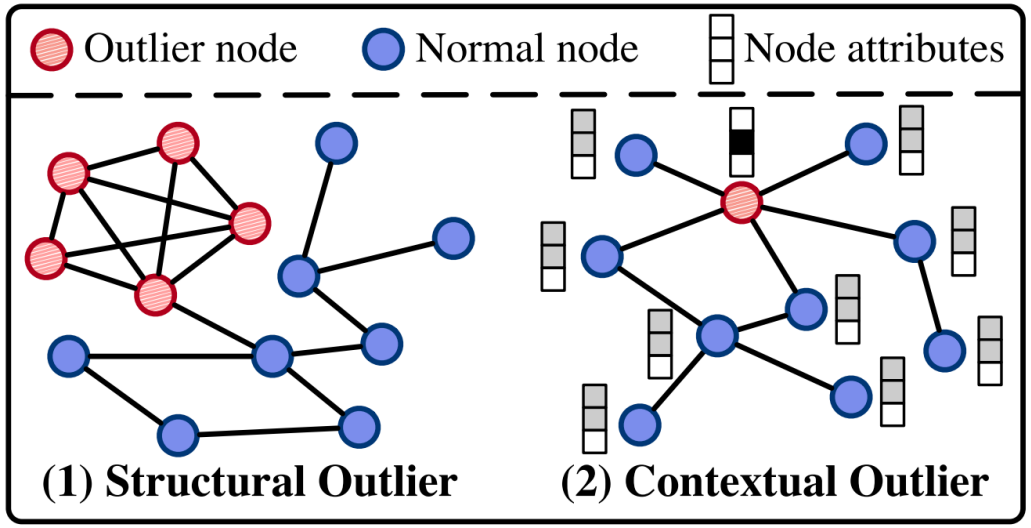
Key Contributions of BOND

- **The first comprehensive benchmark** for *unsupervised outlier node detection*
- **Consolidated taxonomy** of outlier nodes (structural and contextual)
- **Systematic performance flaw** found in existing deep methods
- **Evaluation** of both *detection quality* and *computational efficiency*
- **Reproducible and accessible benchmark toolkit!**

UIC

Taxonomy of Outliers on the Node Level

- **Structural outliers** are densely connected nodes in contrast to sparsely connected regular nodes.
- **Contextual outliers** are nodes whose attributes are significantly different from their neighbor nodes.



3 Types of Benchmarked Datasets

- **Organic dataset**: real graph with organic (real) outliers

  Weibo, Reddit, Disney, Books, Enron, DGraph

- **Injected datasets**: real graph with synthetic outliers

  Cora, Amazon, Flickr

https://github.com/pygod-team/data

- **Generated datasets**: generated graph with synthetic outliers

  Gen_Time, Gen_100, Gen_500, Gen_1000, Gen_5000, Gen_10000

14 Benchmarked Algorithms

- **Non-Graph**
  - Similarity based: LOF (2000)
  - Tree based: IF (2012)
  - MLP+AE: MLPAE (2014)
- **Non-Deep**
  - Cluster: SCAN (2007)
  - MF: Radar (2017), ANOMALOUS (2018)
- **Deep Graph**
  - GAN: GAAN (2020)
  - MLP+AE: DONE (2020), AdONE (2020)
  - GNN+AE: GCNAE (2016), DOMINANT (2019), AnomalyDAE (2020), GUIDE (2021), CONAD (2022)

PyGOD

https://pygod.org

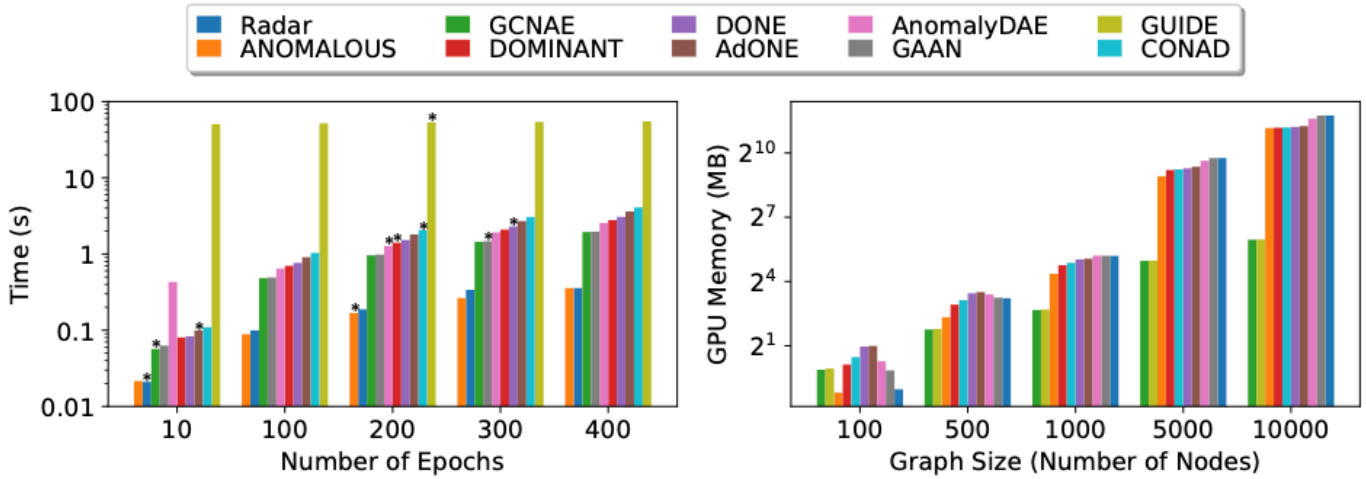
UIC

Result Highlight

- **How effective are the algorithms on detecting synthetic and organic outliers**?
  - No outlier node detection method is universally the best on all datasets
  - Most deep methods evaluated fail to detect organic outliers

- **How do algorithms perform under two types of outliers (structural and contextual)**?
  - No method achieves high detection accuracy for both structural and contextual outliers

- **How efficient are algorithms in terms of time and space**?



BOND Resource

PyGOD

PyGOD: https://pygod.org
Benchmark: https://pygod.org/tree/main/benchmark
Data: https://github.com/pygod-team/data
Docs: https://docs.pygod.org
Email: benchmark@pygod.org

pygod

Presenter: Kay Liu
University of Illinois Chicago

Email: zliu234@uic.edu
Homepage: https://kayzliu.com/
Wechat: kayzliu
Twitter: @kayzliu

kayzliu

UIC