

Hi there research community,

I was directed by the Ethereum Support Program to convey our research direction to the community to gauge interest and applicability so any thoughts would be appreciated (please check out the [github](#)). Here's what we intend to do:

To build a temporal (dynamic) graph representation of all block transactions. Which will allow us to then leverage (and extend) the deep learning frameworks based on dynamic graph neural networks / temporal graph neural networks to extract valuable insight from the transaction network at scale.

For an overview of dynamic graphs please see ["Representation Learning for Dynamic Graphs: A Survey"

by Kazemi, S. et.al. (2020)](<https://www.jmlr.org/papers/volume21/19-447/19-447.pdf>)

The aim is to classify either a single transactions (or wallet) or a series of transactions based on the relative relations from both past and present interactions represented as a transaction graph that evolves over time from the Ethereum blockchain network and develop new TGN (temporal graph neural networks) methodologies in the process.

Typically, we divide the application cases in 3 parts:

- edge classification/prediction (e.g. classify transactions), see ["Temporal Graph Networks for Deep Learning on Dynamic Graphs"

by Rossi, E. et.al. (2020)](<http://arxiv.org/abs/2006.10637>)

- node classification/prediction (e.g. classifying wallet types/holders), ["Influencer Detection with Dynamic Graph Neural Networks"

Tiukhova, E. et.al.(2022)](<https://arxiv.org/abs/2211.09664>)

- graph/subgraph classification/prediction (e.g. transaction load, anomalies) ["Graph Neural Network-Based Anomaly Detection in Multivariate Time Series"

by Deng, A. et.al. (2021)](<https://arxiv.org/abs/2106.06947v1>)

We have quite extensive experience applying these techniques to social networks (predicting future connections via Twitter), road networks (predicting traffic load in a sector of the network and detecting road blockages through network dynamics) and detecting anomalies in multi-input industrial processes and believe there is significant value and insight to be added to the Ethereum network.

Such use cases:

- Peer Discovery
- Network Anomaly detection
- P2P Network Health

These two objectives closely align with two of the academic-grants-wishlist-2023

items:

- Networking & P2P

: "Tools & techniques for analysis of p2p network health, early detection of attacks, identification of p2p bugs, overall data analysis, etc."

- Security

: "Machine Learning on a network level to find anomalies and enable early warning systems for issues that start occurring"

## **Additional background**

- ["Graph-Augmented Normalizing Flows for Anomaly Detection of Multiple Time Series"

Dai, E. et.al. (2022)](<http://arxiv.org/abs/2202.07857>)

- ["Anomaly Detection in Multiplex Dynamic Networks: from Blockchain Security to Brain Disease Prediction"

Behrouz, A. et.al. (2022)](<http://arxiv.org/abs/2211.08378>)

- ["Imperceptible Adversarial Attacks on Discrete-Time Dynamic Graph Models"

Sharma, K. et.al. (2022)]([https://openreview.net/pdf?id=YMrdoXP3x\\_A](https://openreview.net/pdf?id=YMrdoXP3x_A))

- ["Provably expressive temporal graph networks"]

Souza, A. et.al. (2022)](<http://arxiv.org/abs/2209.15059>)

## Application example

We also tested it on a small semi-supervised (mostly unlabeled) bitcoin transaction graph and got promising results

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Bitcoin\_fraud\_detection

1130×1132 429 KB

](<https://ethresear.ch/uploads/default/original/2X/c/ce874368f85a4371c14531c72f682bc07ba98f6a.jpeg>)

Here's a temporal snapshot of blocks 16577361->16577370

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Ethereum\_graph\_temporal\_snapshot

1249×1240 286 KB

](<https://ethresear.ch/uploads/default/original/2X/e/e45bddeaf7061b3e3fe0f02d3af409491a86709c.png>)

## Contact me or reply here

Feel free to contact me or reply here if you're a researcher in this area and wish to collaborate

p.s. Also if you have any input regarding labelling and/or data (apart from what's available via etherscan) we would be very grateful