A Topological Approach to the Structural Analysis of Social Network

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This study explores the Facebook social network's structural intricacies using network analysis and topological data analysis techniques. It employs persistent homology to uncover higher-dimensional topological features that traditional network analysis methods often overlook. Our approach reveals a wealth of information about the network's structure, from tightly-knit communities to influential individuals. The insights gained from this study have potential implications in diverse domains, including social network analysis, community detection, information dissemination strategies, and refining recommendation algorithms on social media platforms.

INTRODUCTION

Social networks are complex structures that provide vast amounts of data. While traditional network analysis methods can provide some insight, they often overlook the complex, high-dimensional structure inherent in these networks. Our study applies topological data analysis (TDA) to social network data, aiming to uncover the underlying structural patterns. Specifically, we computed the persistent homology of a network derived from the "Social Circle: Facebook" dataset from the Stanford Large Network Dataset Collection.

METHODOLOGY (DATA PREPROCESSING)

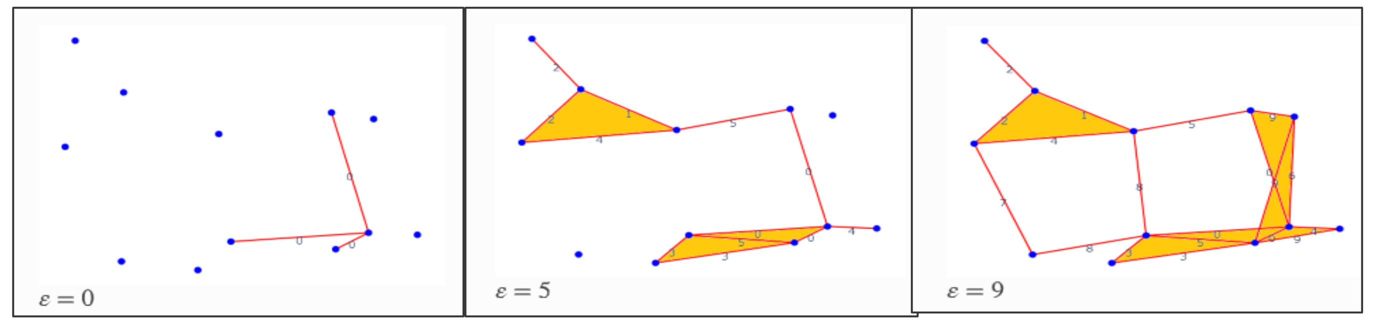
Our Facebook dataset was preprocessed to facilitate a nuanced exploration of the network. We converted edge lists into weighted edges based on various criteria, including uniform weights, random weights, degree-based weights, Jaccard index weights, and inverse shortest path length weights.

METHODOLOGY (NETWORK ANALYSIS)

Various centrality measures were applied to understand the structure of the Facebook social network and the role of individual nodes within it. These include Degree Centrality, Betweenness Centrality, Closeness Centrality, and Eigenvector Centrality.

METHODOLOGY (TDA)

We applied topological data analysis (TDA) to the Facebook social network. This involved transforming the network into a simplicial complex and then computing the persistent homology.



METHODOLOGY (WEIGHTING SCHEME)

Uniform Weights: a weight of 1

Random Weights: a random weight between 0 and 1,

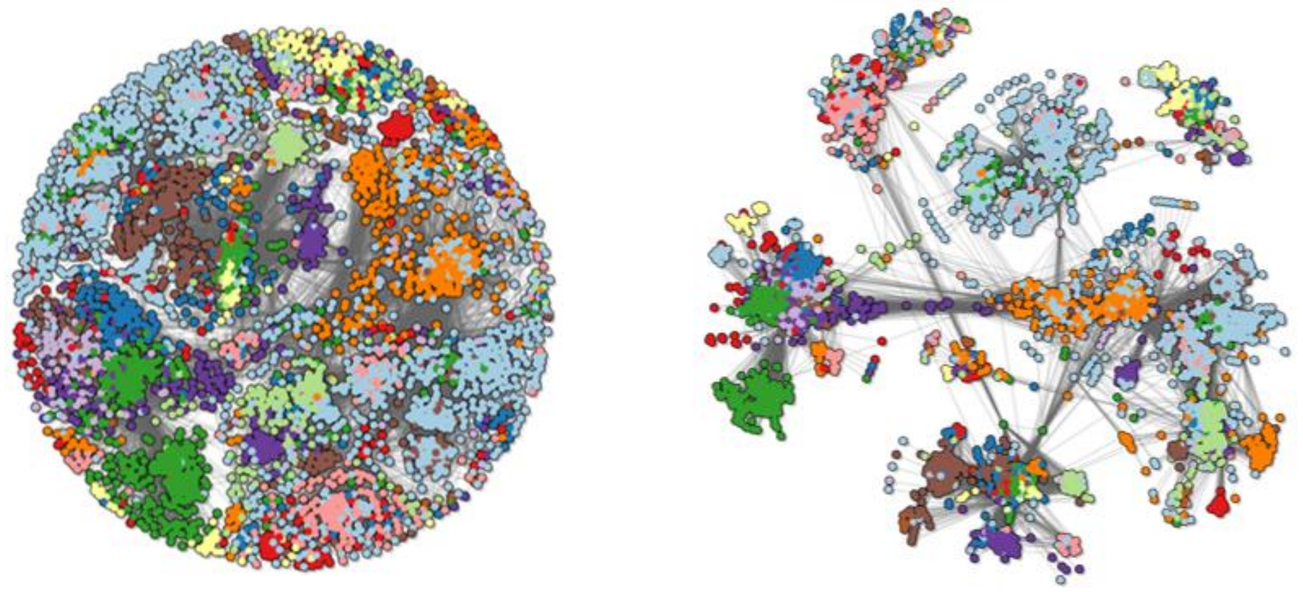
Degree-based Weights: a weight equal to the sum of the degrees of its connected

Jaccard Index: a weight based on the Jaccard Index, which measures the similarity between the neighborhoods of the connected nodes.

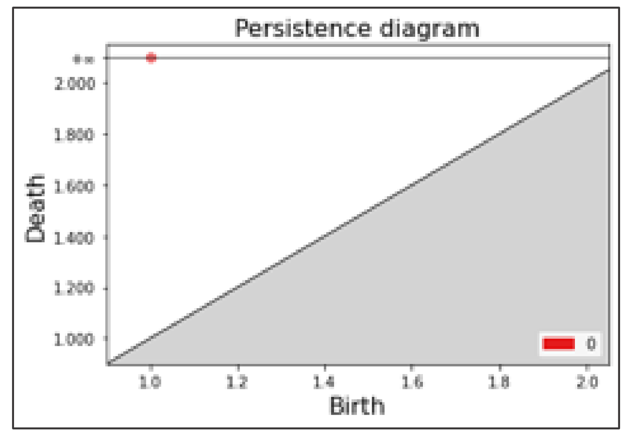
RESULT

We applied persistent homology analysis to the Facebook social network and created persistence diagrams using different edge weights. The diagrams reveal diverse aspects of the network's topology, each highlighting unique facets of the social structure.

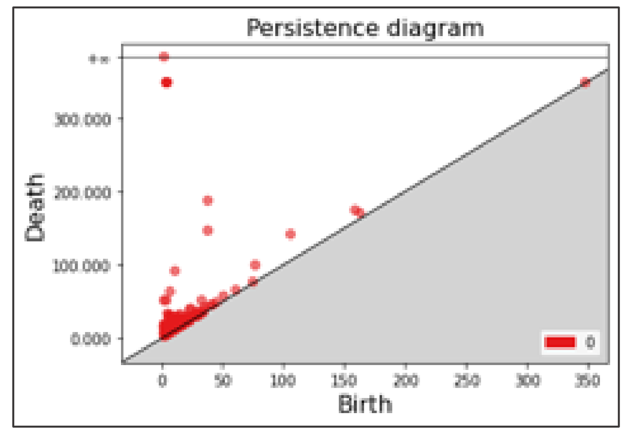
RESULT



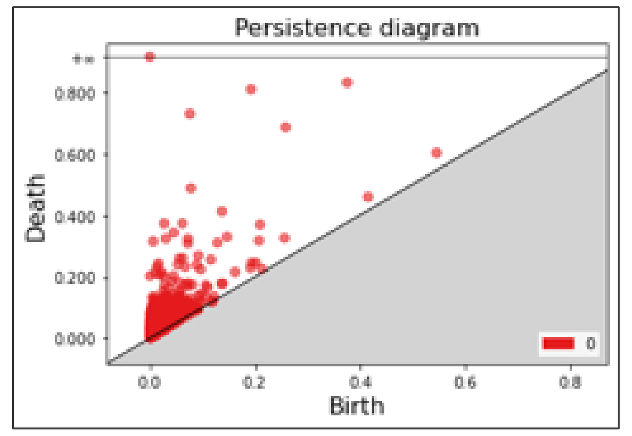
Network Visualization



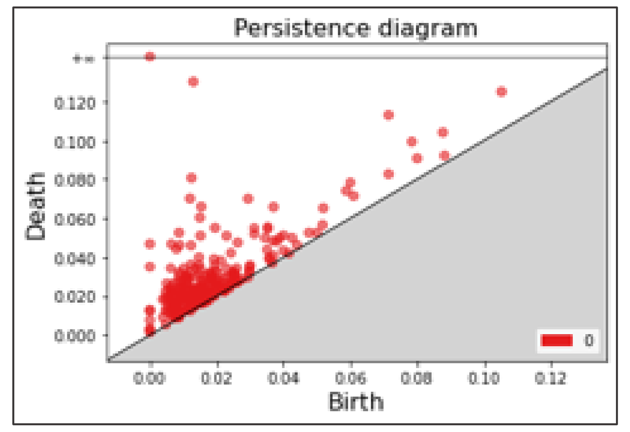
Uniform



Degree Centrality



Random



Jaccard Index

UNDERSTANDING RESULTS

The results of our study provide valuable insights into the underlying structural patterns and relationships in the Facebook social network. The insights can be harnessed in various real-world applications, from improving social media algorithms to understanding human behavior and social dynamics.

CONCLUSION

The use of topological data analysis, specifically persistent homology, has proven to be a powerful tool for uncovering and understanding the complex structures in social networks. It provides a unique perspective that goes beyond traditional graph-theoretic measures, revealing high-dimensional and multi-scale features of the network..

FUTURE WORK

Future research directions include the analysis of dynamic social networks, examination of multilayer networks, integration of topological data analysis with machine learning methods, comparison of different social networks, and combination with other network analysis techniques.

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