SARS-CoV-2 Variant Patterns & Community Detection

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Introduction

Everyone and everything are connected to each other through physical or virtual networks. In the end, networks relate to science, technology (Facebook, Google), business, and nature to a much higher degree than it may seem. Consequently, to understand complex systems, we need to develop a deep understanding of the networks behind them. Independent of the differences in form, size, nature, age, and despite the diversity of complex systems, the structure and the evolution of the networks are driven by a common set of fundamental laws and principles.

Objective & Impact of Professor Bogdan's Research

In Professor Bogdan's research lab, we are applying the latest network sciences and network technologies to analyze SARS-CoV-2 data sets to understand variant patterns, detect community clusters, and predict spread patterns.

We are using Python network libraries, graph theory, and graph analytics to model, analyze, and predict. We are also applying Machine Learning to learn and simulate how pandemic networks evolve. We are also developing new algorithms and network centralities that illuminate certain node properties and make a difference in SARS-CoV-2 community detection applications.

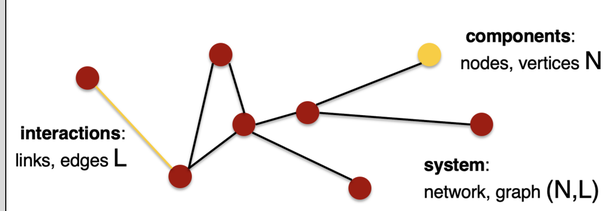
Through all this research, we aim to show the advantages of our innovative functions over standard measures. By learning the genetic evolution of the SARS-CoV-2 through the previous mutants based on the network theory, Professor Bogdan and his team of PhD students aim to make a positive impact in the important science of predicting and preventing future pandemic events.

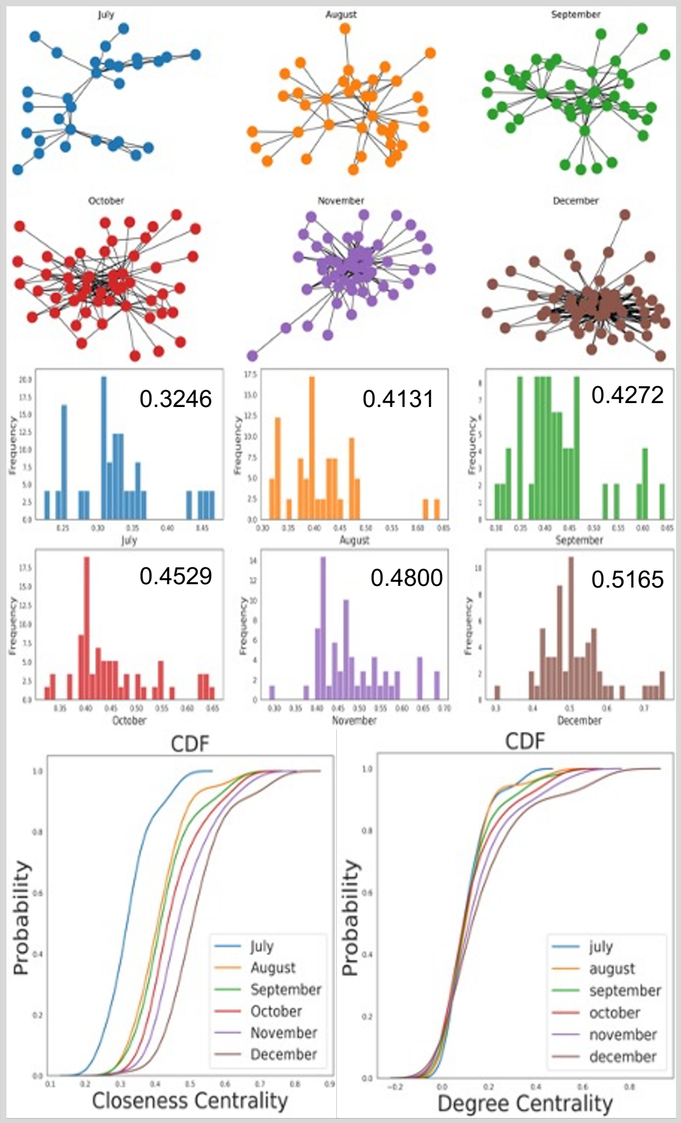
Skills Learned

New Skills Learnt & Applied Step By Step:

1. Python graph libraries: Networkx
2. Foundations of network systems and graph analytics
3. Graph classification: directed, undirected, homogenous, heterogenous
4. Community detection (CD): infer communities or clusters of nodes based on the similarity of node attributes
5. Centralities: closeness, betweenness, degree, and eigenvector
6. Generating key centrality and capture the evolution of SARS-CoV-2 variant network
7. Analyze monthly data trends and predict broader network patterns
8. Learn about graphing neural networks for fast node ranking and CD by the nearest nodes with greater centrality
9. Demonstrate advantages of fractal centrality (FC) and applications to node ranking and CD with custom innovative measures of centrality built by my mentor Xiongye: FC & Node Dimension

COMPONENTS OF A COMPLEX NETWORK SYSTEM





Next Steps and Advice for Future SHINE Students

Next Steps for Me:

1. Learn machine learning
2. Advance my learnings in networks
3. Learn k-means clustering, node classification and link prediction

Advice For Future Students:

1. Shine is not an 'easy' summer program; you will be challenged to learn, think, and ask questions
2. It is ok to have difficulty to understand the concepts or not know how to apply it. But you should ask for help, as your mentors were high schoolers just like us and they are very understanding and supportive.
3. Even if you don't get the exact sub-cohort/group you want, you can still make use of it and relate it to what topic you love most

My STEM Coursework

As a freshman, I learnt the basics of computer programming, algebra/trigonometry and biology, but I had limited insights into how these can be combined in real-world applications. In SHINE, I was introduced to brand new and advanced mathematical and technology concepts, and how to apply them to analyze real world problems. As a result of this experience, I was able to understand the power and value of data and how math and technology can be applied to gain insights into fields like biology. In my sophomore and junior years, I plan apply these learnings into practical applications of my other advanced placement STEM subjects.

Acknowledgements

Thank You To:

1. Professor Bogdan
2. Dr. Katie Mills
3. Xiongye Xiao, PhD student
4. Emily Yamanaka, Center Mentor
5. Jayson Sia
6. Eszter Morvay