Assessing the Effects of Disruptive Events on Spatiotemporal Networks

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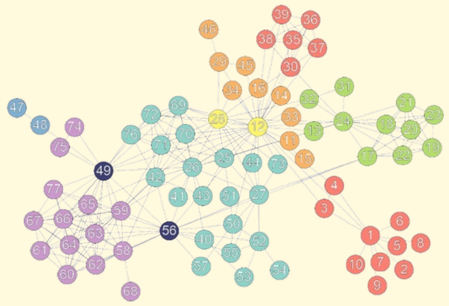
Introduction

Background

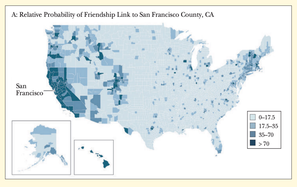
- Disruptive events (such as COVID-19) affect human mobility and communication, **changing physical and virtual community structures**.
- To assess these changes, **community detection** within **spatiotemporal networks** must be performed, detecting changes within communities over space and time.



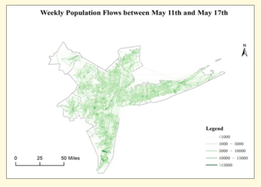
*Community structures are visualized as a **network with nodes and edges**. Nodes represent counties and edges represent **weighted, directional connections** between nodes. Weights are assigned according to the strength of physical/virtual connections. Different colors represent distinct communities (Kuikka, 2021).*

Data

We capture **flow data** from **two sources** to form both **physical and virtual** flow datasets. Both sources aggregate data at a **county level** and have discrete **snapshots** of data during individual periods.



*Virtual: Facebook **Social Connectedness Index**, calculated using friend counts across counties (Bailey et al. 2018)*



*Physical: **Safegraph data**, created using anonymized cellphone location tracking. (Kang et al., 2020)*

Purpose

Research Question

How do disruptive events, such as COVID-19, change physical and virtual community structures?

Objectives

- Develop a **methodology** to **track physical and virtual communities** over time AND **assess structural changes** during disruptive events.
- Conduct a **case study** on COVID-19

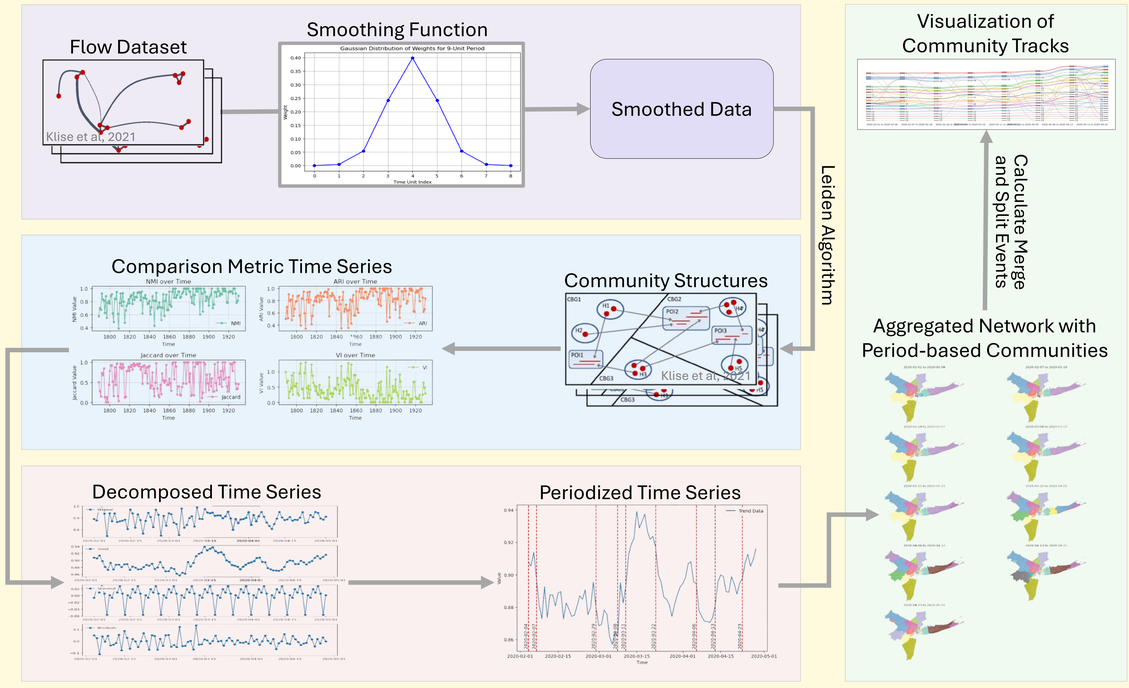
Methods

Data Preparation
Remove noise by smoothing snapshots within the flow dataset
Part 1

Temporal Comparison
Detect communities and compare between snapshots
Part 2

Time Series Periodization
Decompose similarity metrics and segment into periods
Part 3

Evolution Analysis
Aggregate periodized communities to visualize changes
Part 4



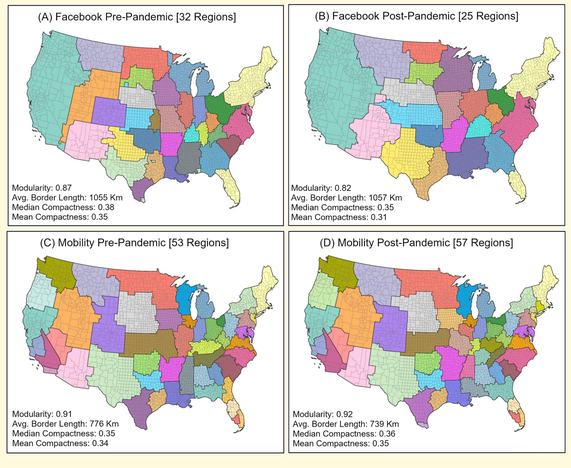
Results

Network	Pre-Period	Post-Period	Adj. Rand	Jaccard	NMI
SafeGraph	2019/3 – 2020/3	2020/4 – 2021/4	0.82	0.70	0.93
Facebook	2015	2021	0.67	0.52	0.83

Various similarity metrics indicating community similarity pre- and post-covid. Higher values indicate greater similarity.

Primary Results

- **Online connections were intensified** (decrease in modularity and number of regions)
- **Long-distance physical travel decreased** (increase in modularity and number of regions)
- **Virtual communities changed more drastically than physical communities** (smaller community similarity metric values)
- We detected many interesting **regional community events,** such as growth, merge, and split events.



Conclusions

Primary Conclusion

Physical interactions became shorter, resulting in more localized geographic communities and greater modularity. Virtual interactions became longer, resulting in larger communities with less modularity.

Impact

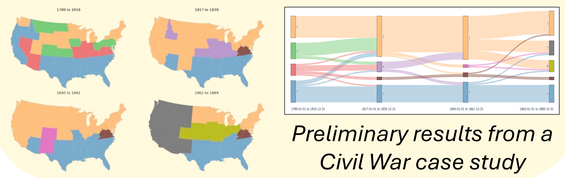
- **Novel methodology** quantitively assesses community evolution, applicable on **wide spatial and temporal scales.**
- **Developed understanding** of how disruptive events affect communities.

Limitations

- We have not proven that the trends found are **specific to the COVID-19 pandemic**, as opposed to being a symptom of global virtualization.

Future Work

- Enhancing **techniques for visualizing** community evolution, e.g. improving Sankey diagrams.
- **Further case studies** on different spatial and temporal scales. We are currently working on studying community evolution during the **Civil War** using **family tree data.**



Preliminary results from a Civil War case study

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