

VASA: mapping spatiotemporal structure of mobility patterns during the COVID-19 pandemic

Evgeny Noi, Alexander Rudolph, Somayeh Dodge

GIScience 2021, Poznan, Poland (Virtual)



UC SANTA BARBARA



I. The problem



Introduction

- First and second order spatial effects violate assumptions of classic inferential statistic (independence and iid)
- Exploratory tools from spatial statistics and econometrics that help us assess phenomena while taking into consideration these spatial effects
 - Moran's I, Geary's C, Ripley's K, etc.
 - ~~Space-time data-mining and visual analytics~~

Problem

- Most common visual display in the geostack (PySAL, GeoDa, ArcGIS, QGIS, spdep, etc.) utilize choropleth maps, where statistically significant clusters (hotspots/coldspots) are denoted in red/blue.
- While this graphical display is ideally suited for purely spatial data, spatiotemporal and multivariate representations are problematic. How do we plot study areas with large number of spatial units?

II. The software



VASA - Visual Analytics for Spatial Associations

- FOSS written on Python
- Ideally suited for exploratory spatial analysis on spatio-temporal areal data (e.g. Census units). Works with vector data.
- Offers several utility functions for spatial aggregation and visualizations



- Check out the [Github repo](#)
- Navigate example [notebooks](#)
- Install via pip (currently on [test](#), alpha version)

```
pip install -i https://test.pypi.org/simple/VASA
```



III. The Case Study



Assessing COVID-19 induced mobility in USA in 2020

- 2 data sources: *SafeGraph* (Open) & *Cuebiq* (Proprietary)
- Approximately 3,200 counties over the period of 2020 (daily data)



General Workflow

0. Import data and clean
1. Create a VASA Object
2. Aggregate by spatial units
3. Downsample to Week
4. Calculate Local Moran's I for each week and county
5. Map *recency* | *consistency* | *week number* to visual variables
6. Plot on a graphic display

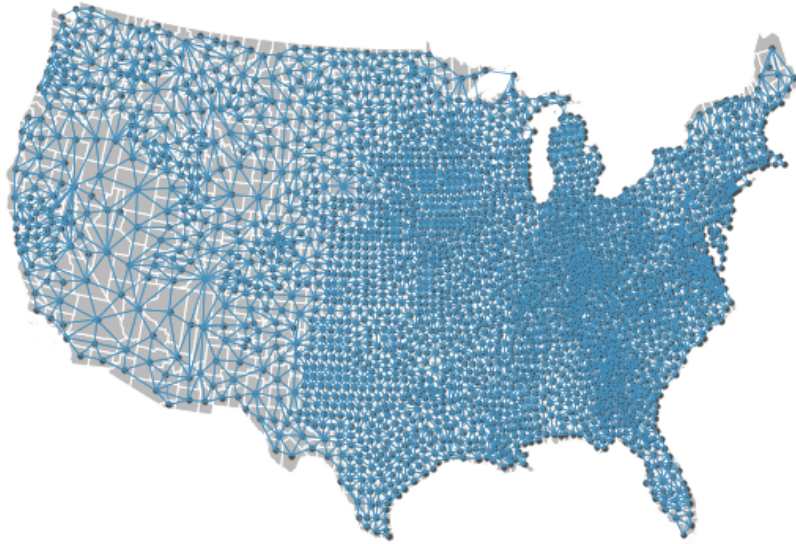
Create a VASA Object

```
v = VASA(  
    df=data,  
    gdf=counties_map,  
    group_summary=lambda g: g[:2], # state level  
    df_group_col="fips",  
    gdf_group_col="GEOID",  
    date_col="ds_m4",  
    temp_res="week",  
    date_format="%Y-%m-%d"  
) .group()
```

Build Spatial Weights Matrix

Since VASA utilizes Moran's I , we need to construct spatial weights matrix (SWM). There are different methods to create SWM (Rook's, Queen's, kNN, etc.). Please refer to [PySAL docs](#) to learn more.

```
v.show_weights_connection(k=3, type="union")
```



Recency and Consistency Map

Better suited to study the aggregate (summary-level) details.

```
stacked.plot_both(a=2500, b=600)
```

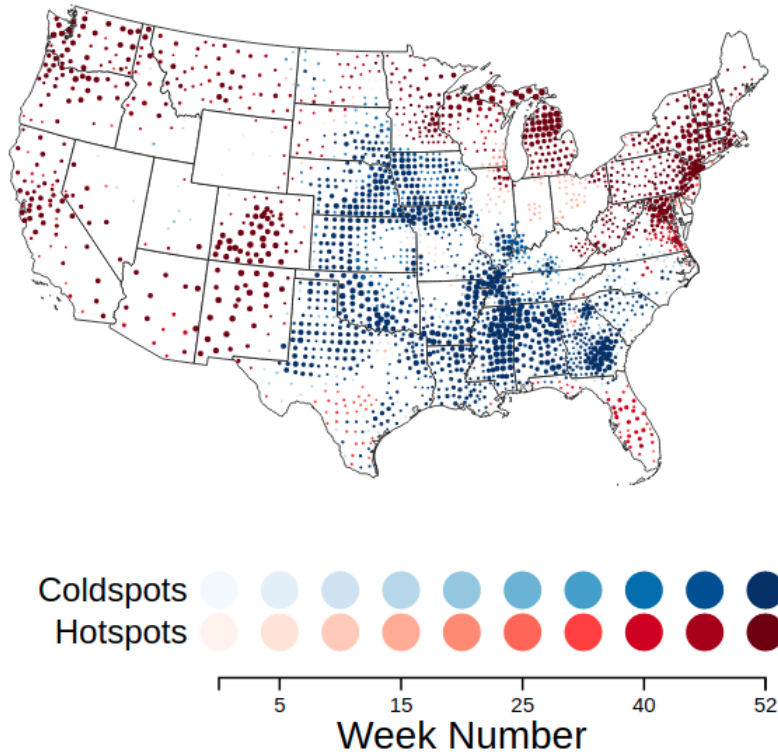
hotspots: high values co-located with other high values.

coldspots: low values co-located with other low values.

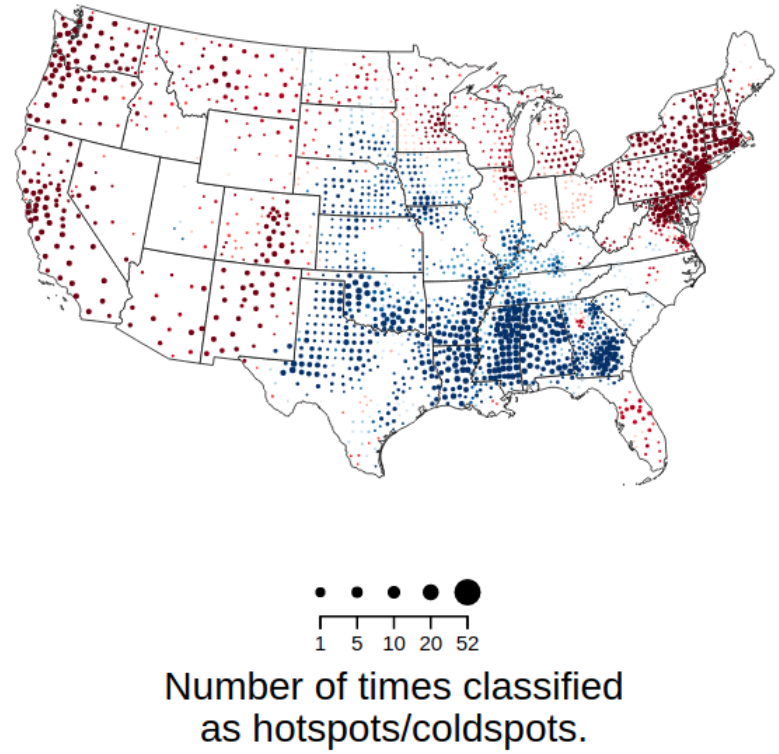
Clustering **consistency** is illustrated by **size**.

Clustering **recency** is depicted by **color intensity**.

Percentage of Sheltered in Place (Cuebiq)



Percentage of Sheltered in Place (Safegraph)



Line-path scatter plot

Better suited to study the finer (object-level) details.

```
from VASA.scatter import Scatter
sc = Scatter(v)
sc.plot(highlight="06") # this filters out CA
```

hotspots: high values co-located with other high values.

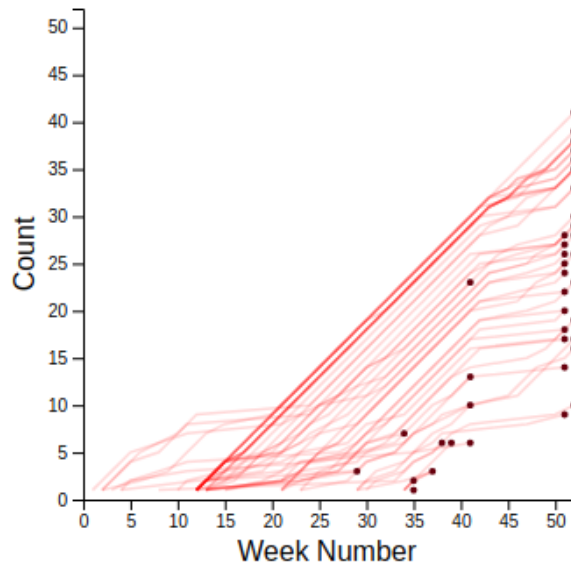
coldspots: low values co-located with other low values.

Week number is mapped onto X-axis.

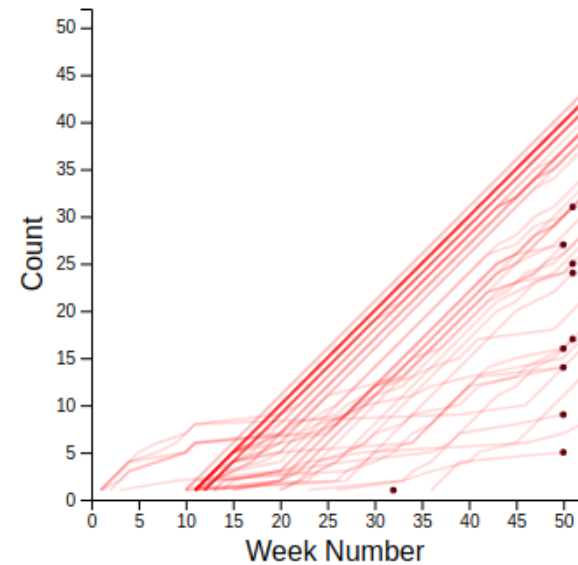
Number of times classified as hs/cs is mapped onto Y-axis.

Social distancing in California

Percentage of Sheltered in Place (Cuebiq)

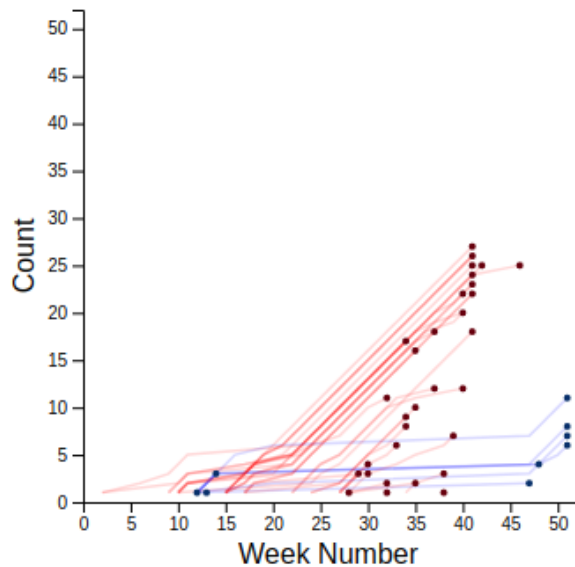


Percentage of Sheltered in Place (Safegraph)

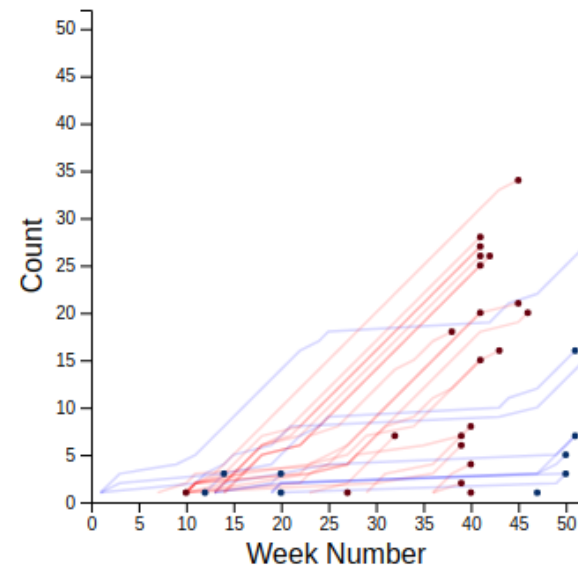


Social distancing in Florida

Percentage of Sheltered in Place (Cuebiq)



Percentage of Sheltered in Place (Safegraph)



IV. Conclusion



- Proposed methodology provides a robust framework for assessing spatiotemporal structure of the data (NOT only mobility!).
- VASA allows exploratory spatial data analysis at the object-level and summary-level, which makes comparison of multiple spatiotemporal series easy
- VASA adds novel visual displays to traditional choropleth mapping prevalent in spatial econometrics
- *Planned: Adding more visual displays for micro-scale analysis on areal data (e.g. LA Census Block Groups ~ 25,000)*

Questions?

Thank you for Zoom-listening!



Evgeny Noi Alex Rudolph Somayah Dodge

noi@ucsb.edu

geog-move@ucsb.edu



UC SANTA BARBARA



GIScience 2021



The authors gratefully acknowledge the support from the National Science Foundation
Award BCS # 2043202 "CAREER: Modeling Movement and Behavior Responses to
Environmental Disruptions".