Capturing Spatial and Temporal Variation in Behaviors Related to COVID-19 using ENSIGN

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Nonpharmaceutical Interventions (NPIs)

“Nonpharmaceutical Interventions (NPIs) are actions, apart from getting vaccinated and taking medicine, that people and communities can take to help slow the spread of illnesses.”

Examples

Wearing Masks
Social Distancing
Limiting Mobility
Closures
Increased Hand Washing
Cleaning High-Touch Surfaces

“NPIs are among the best ways of controlling pandemic illness when vaccines are not yet available.”

Source: https://www.cdc.gov/nonpharmaceutical-interventions/index.html
Efficacy Both Complicated and Complex

- Finding quality measurables connecting the many NPIs to adherence
- Understanding connections between policy, culture and outcomes

Decomposition-Identified Correlations Between Work Mobility and Cases in March
C3.ai Data Lake

Access unified, analysis-ready COVID-19 data, at no charge


Johns Hopkins University – Daily Case Counts

University of Oxford – Response Tracker (Closures)

Google – Workplace Mobility Data

Combined Data – Merged, Binned and Ready to Decompose
**ENSIGN: Tensor Decompositions at Scale**

```python
In [30]:
import numpy as np
import pandas as pd

import ensign.sptensor as sp
import ensign.csv2tensor as c2t
import ensign.cp_decomp as cpd
import ensign.visualise as vis

In [31]:
work_data = pd.read_csv('data/work_mobility_adherence_cases.csv')
work_data
```

<table>
<thead>
<tr>
<th>country</th>
<th>date</th>
<th>work_closure</th>
<th>work_mobility</th>
<th>cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Afghanistan</td>
<td>2020-02-15</td>
<td>0</td>
<td>-28</td>
<td>0</td>
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<tr>
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<td>2020-08-28</td>
<td>1</td>
<td>-15</td>
<td>79</td>
</tr>
</tbody>
</table>

24130 rows x 5 columns

```python
In [22]:
tensor = c2t.csv2tensor('data/work_mobility_adherence_cases.csv',
                      columns=['country', 'date', 'work_closure', 'work_mobility', 'cases'],
                      types=['str', 'date', 'int64', 'int64', 'int64'],
                      blinding=["none", "none", "none", "blasize=15", "log16"])

In [23]:
decomp = cpd.cp_apptensor(tensor, 190)

In [24]:
import plotlib inline
vis.plot_component(decomp, 22)
```

![Component 22](image1)

![Component 23](image2)
Revealing Patterns and Correlations

Spikes in European Cases During July and August

In Russia and Western Europe during the months of July and August, mobility returned to normal and cases spiked by 1,000 per day.

The new cases correlate with workplace mobility on the weekends suggesting that re-openings of cafes and restaurants played a role in the spikes.
Revealing Patterns and Correlations

In Taiwan throughout the entire duration of the pandemic, there were no changes in workplace mobility yet there were very few cases per day.

Therefore some other non-pharmaceutical intervention is needed to explain the lack of cases in Taiwan.
Decompositions Find Pandemic Phases

Capturing Spatial and Temporal Variation in Behaviors and Cases

Behavior of all countries pre-pandemic clustered in a single component

- No workplace closures
- No change in mobility
- No cases per day

Behavior of Central European countries during April and May

- Workplace closures
- Decrease in mobility
- ~100 cases per day

Behavior of Eastern European and Middle Eastern countries during May and June

- Workplace closures
- Decrease in mobility
- ~1000 cases per day

Behavior of Central American countries during July and August

- Workplace closures
- Small decrease in mobility
- >1000 cases per day
Conclusion

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ENSIGN 4.3

- Decompositions
  - Shared and Distributed Memory
- Tensor formation and post-processing tools
- Python 3 API
- Available for Government & Research Use

Relevant Papers

- Multiscale Data Analysis Using Binning, Tensor Decompositions, and Backtracking
  HPEC, Sep 2020
- Fast and Scalable Distributed Tensor Decompositions
  HPEC, Sep 2019
- A Quantitative and Qualitative Analysis of Tensor Decompositions on Spatiotemporal Data
  HPEC, Sep 2017