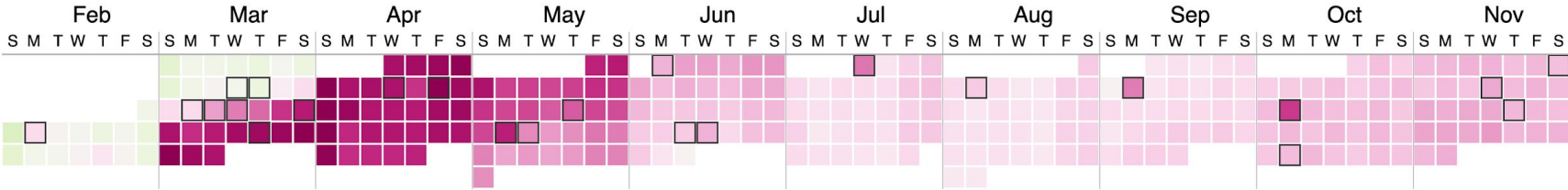


Visualizing Mobility and COVID-19

Lily Bryant, Frank Yu, James Yoo

CPSC 547 – December 10, 2020



Overview

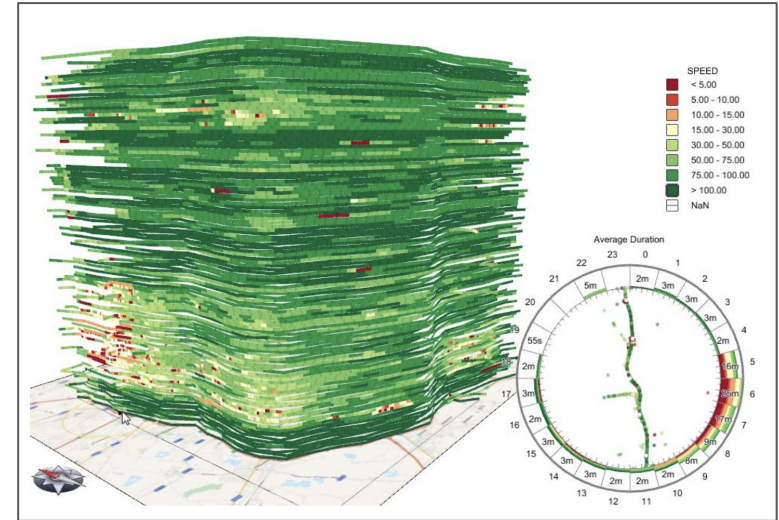
- **Mobility**
 - Motivation
 - COVID-19 Pandemic
- **Related Work**
- **Data & Task Abstraction**
 - Usage Scenarios
- **Solution Overview**
 - What is an interactive explainer?
 - Tools
- **Proposed Solution**
 - Responsible COVID-19 Visualizations
 - Mockups
- **Solution & Implementation**
 - Visualizations
 - Demonstration
- **Discussion & Future Work**
- **Conclusion**

Mobility & Motivation

What is *Mobility*?

*the study of how individual humans move within a network or system**

- common in the field of urban planning
- frequent questions:
 - Where do people gather?
 - What are the peak times of movement for a location?
 - How does mobility change over time?



an overlay of routes on a map, colour indicating speed (Andrienko et al.)

Why Mobility and COVID-19?

The COVID-19 pandemic has arguably been the most transformative change of our society in recent memory.

- a significant number of people are now working remotely from home
- heavy travel restrictions, such as border closures, are affecting movement
- major events have been cancelled or postponed, for example:
 - Tokyo 2020 Olympic Games
 - Professional sports league seasons
 - Parliamentary sessions

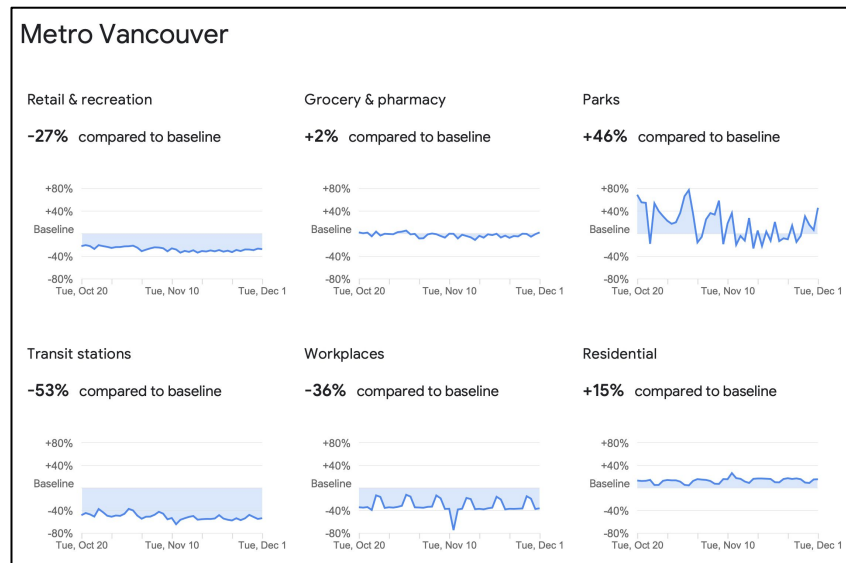


a stadium with an empty audience, 2020 (Wall Street Journal)

Related Work

COVID-19 Google Community Mobility Reports

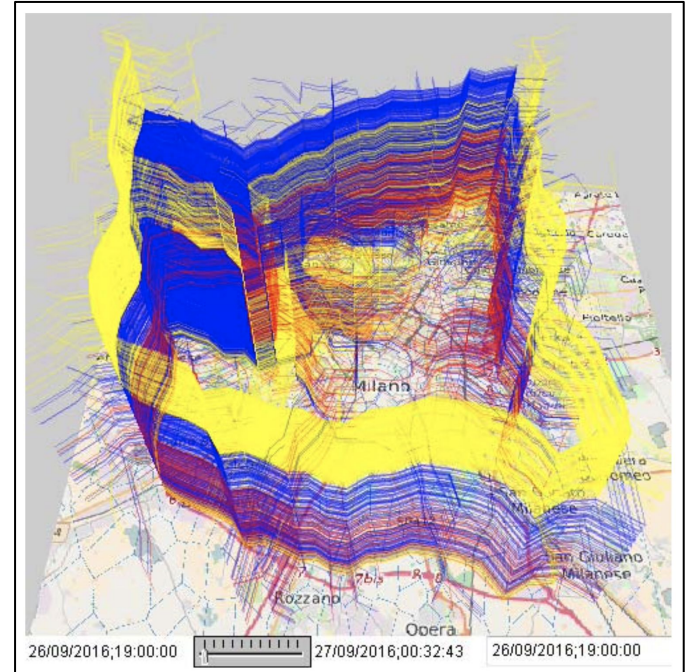
- automatically-generated PDF reports which show changes in mobility across preset categories
- data updated by Google frequently
- small multiples of line charts with area shading
- limitations:
 - separate downloads for regions
 - pairwise/one-to-many comparisons not supported



an excerpt for Metro Vancouver from a mobility report generated for BC (Google)

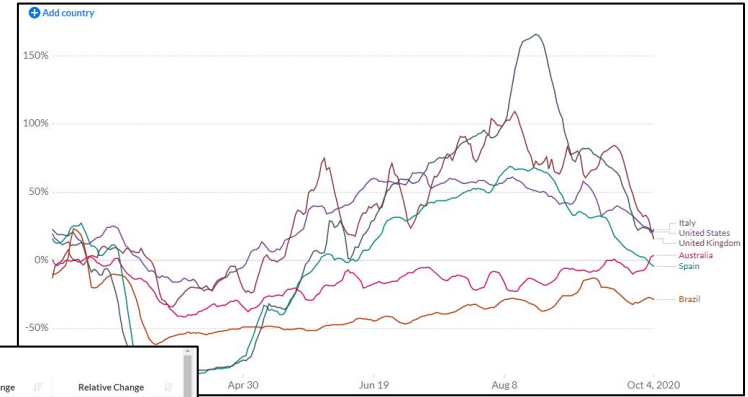
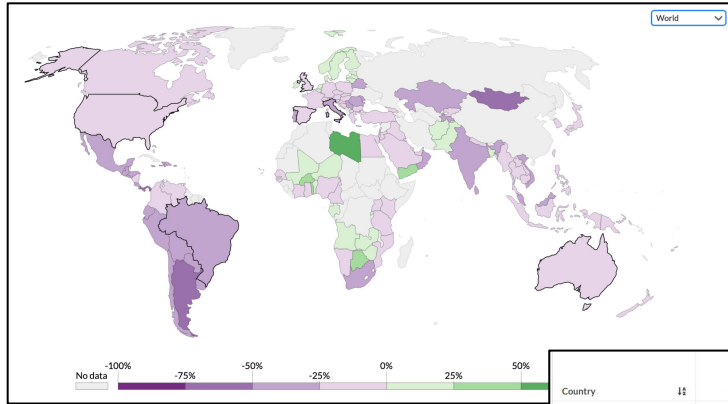
Visualizing Mobility and Transportation

- advances in analytics and computing power make data collection *easy*
- a huge amount of data makes visualizing mobility *hard*
- lesson learned:
 - select a subset of categories to produce a focused set of visualizations



a flow of traffic data around Milan (Andrienko et al.)

Our World in Data - Coronavirus Pandemic Data



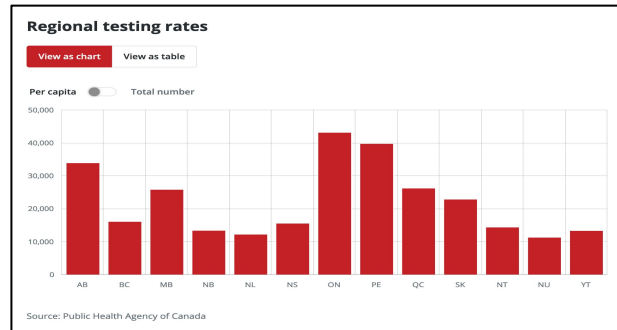
Country	Start	End	Parks percent	Absolute Change	Relative Change
Afghanistan	1.00% in Feb 17	6.00% in Oct 4	+5.00 pp	+500%	
Angola	-0.67% in Feb 17	15.71% in Oct 4	+16.38 pp	+2456%	
Antigua and Barbuda	-1.00% in Feb 17	47.71% in Oct 4	+48.71 pp	+4871%	
Argentina	-13.33% in Feb 17	-71.00% in Oct 4	-57.67 pp	-433%	
Aruba	10.67% in Feb 17	3.86% in Oct 4	-6.81 pp	-64%	
Australia	0.33% in Feb 17	3.71% in Oct 4	+3.38 pp	+1015%	
Austria	39.67% in Feb 17	16.43% in Oct 4	-23.24 pp	-59%	
Bahamas	13.00% in Feb 17	-12.71% in Oct 4	-25.71 pp	-198%	
Bahrain	-9.67% in Feb 17	-26.29% in Oct 4	-16.62 pp	-172%	
Bangladesh	6.00% in Feb 17	2.29% in Oct 4	-3.71 pp	-62%	
Barbados	3.00% in Feb 17	-0.29% in Oct 4	-3.29 pp	-110%	
Belarus	11.67% in Feb 17	6.86% in Oct 4	-4.81 pp	-41%	
Belgium	2.33% in Feb 17	10.57% in Oct 4	+8.24 pp	+353%	
Belize	11.33% in Feb 17	-6.29% in Oct 4	-17.62 pp	-155%	
Benin	-1.67% in Feb 17	7.71% in Oct 4	+9.38 pp	+563%	
Bolivia	1.67% in Feb 17	-28.71% in Oct 4	-30.38 pp	-1822%	
Bosnia and Herzegovina	18.33% in Feb 17	5.71% in Oct 4	-12.62 pp	-69%	
Botswana	-6.33% in Feb 17	37.43% in Oct 4	+43.76 pp	+691%	
Brazil	-10.00% in Feb 17	-28.86% in Oct 4	-18.86 pp	-189%	
Bulgaria	27.67% in Feb 17	33.57% in Oct 4	+5.90 pp	+21%	
Burkina Faso	-2.67% in Feb 17	18.57% in Oct 4	+21.24 pp	+796%	
Cambodia	1.33% in Feb 17	-17.86% in Oct 4	-19.19 pp	-1440%	
Cameroon	0.67% in Feb 17	-14.29% in Oct 4	-14.95 pp	-2242%	
Canada	38.00% in Feb 17	54.43% in Oct 4	+16.43 pp	+43%	
Cape Verde	-7.33% in Feb 17	-24.14% in Oct 4	-16.81 pp	-231%	

Feb 17, 2020 Dec 4, 2020

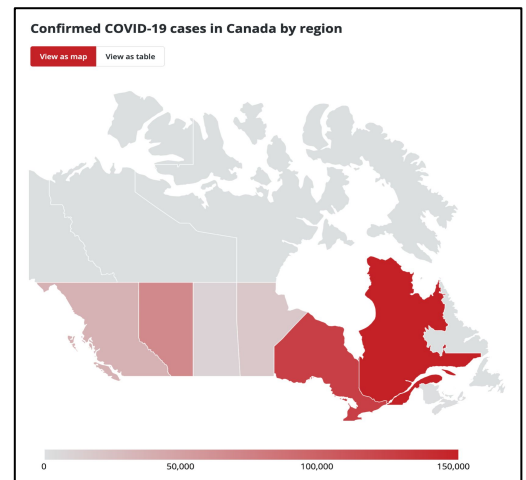
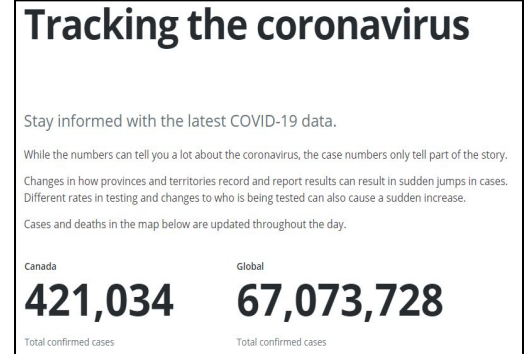
interactive choropleth map, line chart, and table views visualizing changes in mobility for parks around the world (Our World in Data, Oxford Martin School)

CBC Coronavirus Tracker

- interactive webpage with embedded visualizations
- explanations are given for metrics such as:
 - *Daily new cases*
 - *Cumulative cases*
 - *Regional testing rates*
- strong focus on Canadian data and course of COVID-19



bar graph showing regional testing rates for provinces and territories (CBC News)



article introduction and choropleth map visualization for confirmed cases by region (CBC News)

Data & Task Abstraction

Data Overview

Google COVID-19 Mobility Dataset			
Attribute name	Type	Range/Unique Val.	Description
Provinces & Territories	Categorical	13	Canadian provinces and territories
Date	Sequential	2020-02-15 to 2020-12-01	Date range for which mobility data was collected
Retail and Recreation Change From Baseline	Quantitative	-90.0 - 109.0	Percent Change from Baseline
Grocery and Pharmacy Change From Baseline	Quantitative	-59.0 - 114.0	
Parks Percent Change From Baseline	Quantitative	-79.0 - 578.0	
Transit Station Percent Change From Baseline	Quantitative	-80 - 39.0	
Workplace Percent Change From Baseline	Quantitative	-81.0 - 16.0	
Residential Percent Change From Baseline	Quantitative	-5.0 - 34.0	

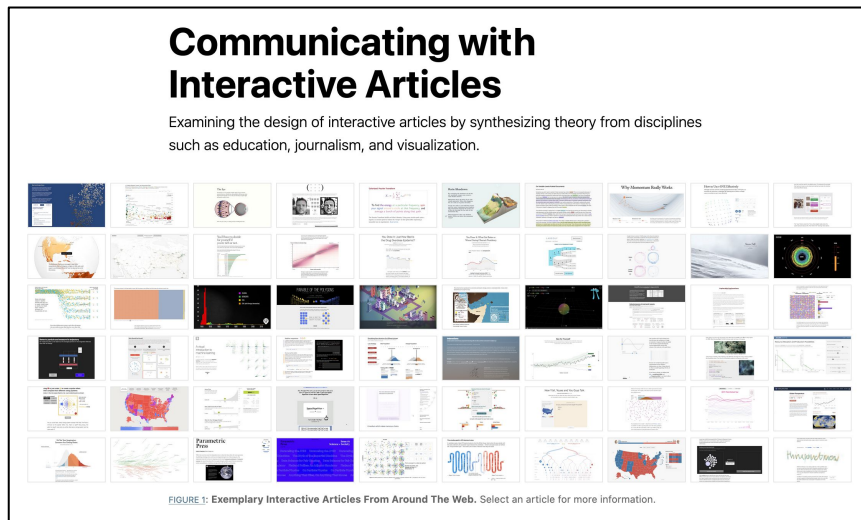
Task Abstractions & Usage Scenarios

- Comparing daily geographical mobility data by region
- Comparing trends over time
- Comparing provincial versus national trends
- Comparing expected mobility between regions
- Identifying outliers within general trends

Project Overview

What is an Interactive Explainer?

- online medium that interleaves interactive visualizations with a narrative about data
- popular with knowledge experts and laypeople alike
- well-suited for articles for individuals who are not domain-knowledge experts



splash page of an interactive article about interactive articles (Distill.pub)

What tools did we use?

Tool	Library	Usage
Javascript	D3	All Visualizations
	TopoJSON	Map Visualizations
HTML/CSS	-	Interactive Explainer Article
Python	-	Data Processing

Proposed Solution

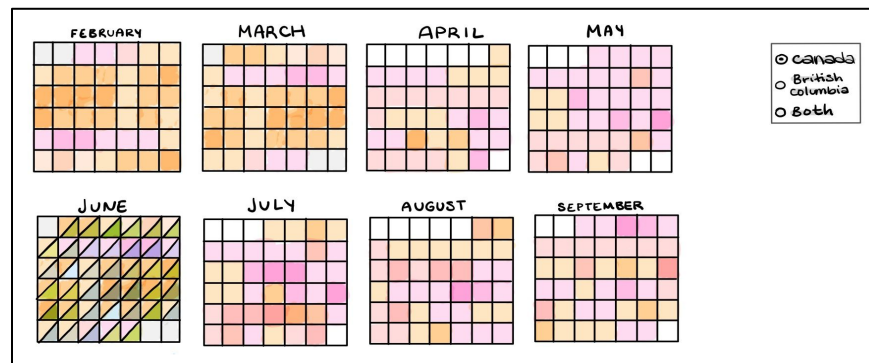
What our visualization *is not*

- a visualization that attempts to model the spread of the COVID-19 virus ✘
- a visualization that attempts to make inferences or predictions about the future spread of the COVID-19 virus ✘

We do not have the necessary training in epidemiology or statistics to ethically and responsibly tackle these problems.

Select Visualization Mockups

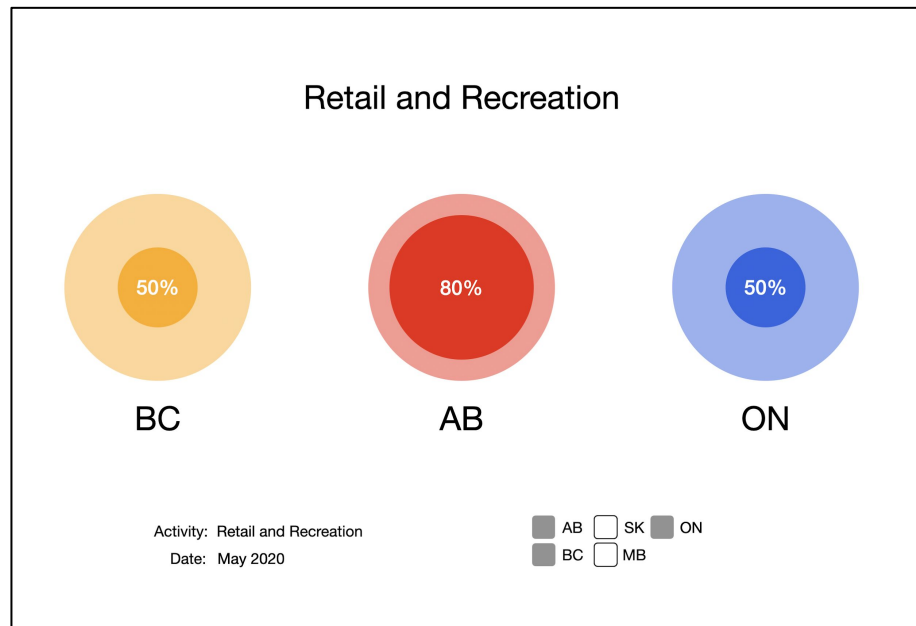
- usage scenarios:
 - comparing outliers against general trends
 - comparing provincial versus national trends
- limitation:
 - trend comparison using a split-colour cell is visually challenging



a mockup of a calendar heatmap visualization for COVID-19 mobility (Lily Bryant)

Select Visualization Mockups

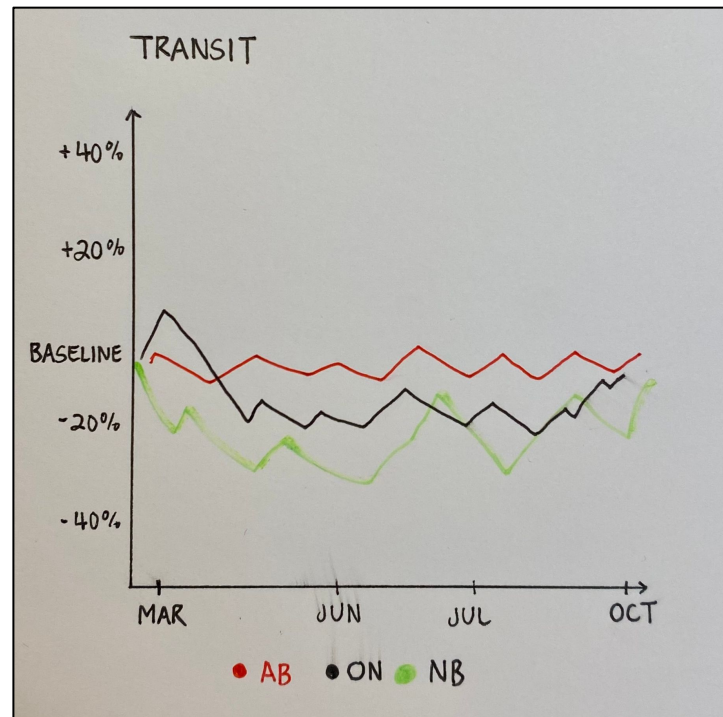
- usage scenario:
 - comparing mobility trends for regions for a selected time period
- limitations:
 - comparing area is *hard*
 - How do we represent negative changes in mobility with this idiom?
 - Is this really better than a simple line graph?



a very early mockup for comparing mobility changes for the Retail and Recreation category (James Yoo)

Select Visualization Mockups

- usage scenario:
 - comparing mobility trends for regions for a selected time period
- overlay of line charts
 - 1 line = 1 province
- enables comparisons between provinces and territories



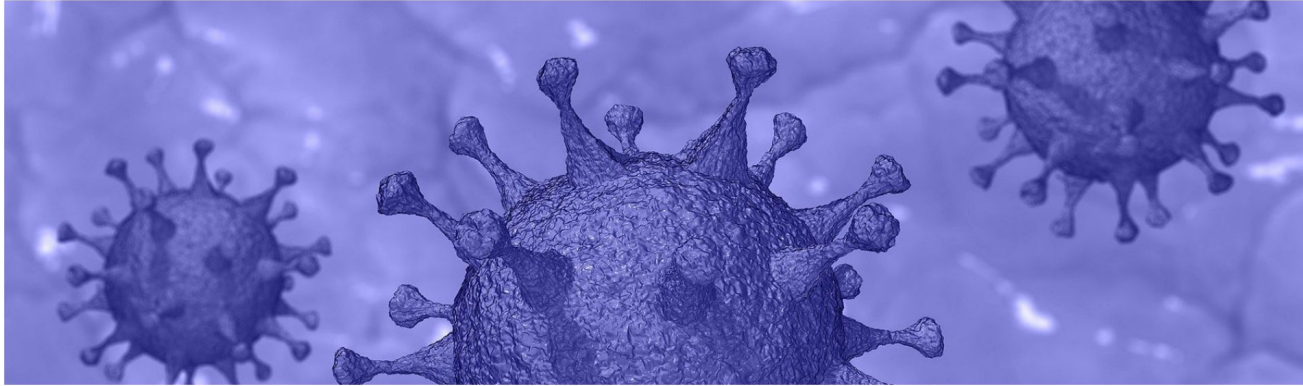
a mockup of a vis with overlaid line graphs for mobility changes in the Transit Category (James Yoo)

Solution & Implementation

Visualizing Mobility and COVID-19

Authors: Lily Bryant, Frank Yu, James Yoo

December 6, 2020



"The COVID-19 pandemic is without a doubt the largest event in recent memory to have disrupted the lives of billions of people on a global scale. Many across the globe have changed their daily routines: how they work, play, and otherwise spend their time." [1]

While the pandemic is now a constant in daily life, the ways in which society has adapted its mobility is ever-changing, with factors such as seasonality and changes in public policy directly affecting movement. In this interactive explainer article, we will detail changes in mobility in Canada during the COVID-19 pandemic, with emphasis on the province of British Columbia, through a series of visualizations. "Furthermore, we will not be visualizing or generating any data on how COVID-19 progresses in a region as we are not experts in epidemiology, and presenting data in this space would be unethical." [1] Instead, our visualizations and data will be centered on the following six mobility categories:

Discussion & Future Work

Fundamental Limitations

- **Choropleth and Surprise Maps**
 - does not work well for small regions, e.g. PEI
 - surprise map data requires handcrafted models and priors
- **BC/Canada Calendar Heatmap**
 - discerning shade differences in colour channels can be challenging
- **Provincial Mobility Comparison Line Charts**
 - efficacy of comparing between regions becomes difficult as more regions are selected

Future Work

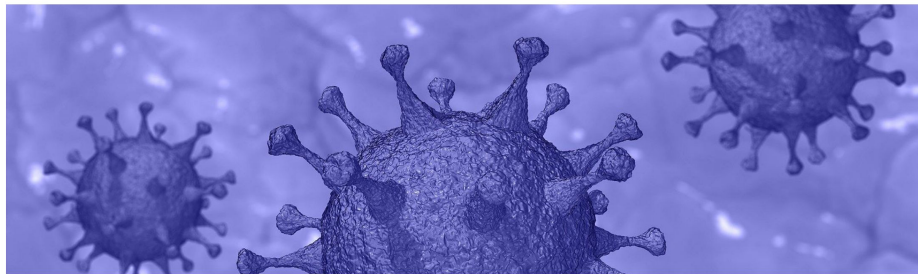
- **Decouple from Observable**
 - non-trivial performance overhead
 - the platform itself is not open-source
 - payment is required for large-scale collaborative development
- **Improve models and priors used for surprise maps**
- **Automatically download and process Google COVID-19 Mobility Dataset**
- **UI refinements and bug fixes**
 - map visualizations: improve performance when scrubbing
 - calendar heatmap: horizontal layout will require modification with additional data
 - line charts: tooltips available for only a single mark at a time

Final Thoughts

Visualizing Mobility and COVID-19

Authors: Lily Bryant, Frank Yu, James Yoo

December 6, 2020



"The COVID-19 pandemic is without a doubt the largest event in recent memory to have disrupted the lives of billions of people on a global scale. Many across the globe have changed their daily routines: how they work, play, and otherwise spend their time."^[1]

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- Workplaces
- Transit Stations
- Residential
- Parks
- Retail and Recreation
- Grocery and Pharmacy

splash page of our interactive explainer: *Visualizing Mobility and COVID-19*

Overview

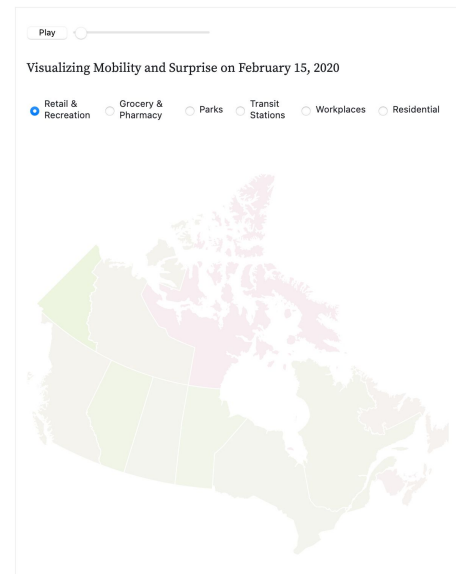
Choropleth Map

Our first visualization provides a choropleth map representation of Canadian mobility. From this, we can see per-day differences and similarities across every province and territory. We also provide a play button if you wish to see an animated version of this visualization. With this animated version, we can already start to see some trends emerge in the data. If you're curious as to the exact values for a province or territory, simply hover over the region of interest and a box will tell you the exact percentage change. Regions, where there is missing data, are represented with a light grey.

Surprise Map

While choropleth maps can show a lot of information, we should take note of their limitations. For example, what if we see a 50 percent increase above baseline in both British Columbia and Nova Scotia? Does this mean that we should view these results as equally surprising or should we be more surprised that a province with a lower population (like Nova Scotia) has the same percentage increase in mobility as a province with a larger population (British Columbia)? To answer this question, we present a Surprise Map visualization for the mobility data to show if there are any anomalies in interprovincial mobility.

Surprise Maps were originally introduced by Michael Correll and Jeffrey Heer as an alternative to standard choropleth maps^[2] and allow us to see if there are any anomalies or points of interest that we should explicitly focus on. In this visualization, we present the mobility data as a signed surprise value rather than a percentage change in mobility. The signed surprise shows if the value of mobility that we see is above or below the expected amount. Two prior models determine the expectation. The first model assumes that the mobility between provinces should be



excerpt from our interactive explainer: *Visualizing Mobility and COVID-19*

hosted on: jyoo980.github.io/vis.html

(best on Firefox)