Necklace Maps for COVID-19 Visualization

Mary Abikoye (temiabik@student.ubc.ca), Minglong Li (limnglng@cs.ubc.ca), Jocelyn Minns (jminns@cs.ubc.ca)

1. Introduction

Coronavirus are a large group of viruses that cause respiratory infection which ranges from common cold to more severe diseases e.g SARS-COV(China 2003), MERS-COV(Saudi Arabia-2012), SARS-COV2(China - 2019). In January 2020, SARS-COV2 also known as COVID-19 began to become an immediate concern to many countries and in March of that year was declared a pandemic. Since then, data regarding COVID-19 case numbers have become critical to understanding how this disease affects people around the world.

In December 2020, the FDA authorized two coronavirus vaccines pfizer-BioNTech(BNT162b2) and Moderna(mRNA-1273), both initially reported with a high efficiency of 95%. Since then there have been 7 approved vaccines by WHO and 23 approved vaccines by various countries around the world.

Throughout the COVID-19 pandemic, governments have implemented different policies to combat the spread of the virus. The Stringency Index is a project that aims to collect information on the policies taken by worldwide governments and compile them into a value from 0 to 100 depending on the strictness of these policies. This gives the public a better understanding of the approaches taken in each country.

As the pandemic has unfolded, many have looked for tools to better examine and understand the current situation. Dozens of government agencies and news outlets have provided public access to tools that allow people to examine many of the factors around the COVID-19 pandemic, such as case numbers, hospitalizations and vaccine rates.

For this project we intend to implement a thematic map, known as Necklace maps, to visualize three major factors of the COVID-19 pandemic: confirmed COVID-19 cases, vaccination rates and the stringency index.

Necklace map is a form of visualization that combines elements of proportional symbols maps and boundary labeling. The symbols are placed inside the corresponding intervals. The projection maps each region of the input to a contiguous interval on the necklace in such a way that the interval captures the global location of the region with respect to the necklace.

Our project focuses on examining two research questions. **R1: Does vaccination rate affect COVID-19 confirmed cases?** and **R2: Does stringency index affect COVID-19 confirmed cases?**

2. Related Work

Choropleth maps are a thematic map that is well suited to show quantitative attributes of geographic data [1], however there can be significant drawbacks to relying on this method. When the quantitative attribute is focused on the population, these maps can overemphasize large geographic areas regardless of their sparse population due to their strong visual weight. Different thematic maps have been proposed over the years and while they may each have their own advantages, no clear alternative has been identified [2]. Additionally, choropleth maps can be ill suited for the task of observing changes over time in the data. In a study on animated choropleth maps, the phenomenon of change blindness hindered the user from perceiving changes in the data [3].

Epidemiological data is commonly visualized using choropleth maps, though careful consideration must be given to ensure these maps can be useful to epidemiologists. Variations in classifying the data must be considered to accurately inform those relying on these visualizations[4]. The recent COVID-19 pandemic has seen a surge in visualization approaches[6] including a heavy reliance on choropleth maps, however the limitations of these maps must be considered when creating visualizations to avoid potential misinformation [7].

Necklace maps[8] are a proposed alternative to the choropleth maps. This method combines proportional symbol maps and boundary labeling to create a one-dimensional curve containing scaled symbols corresponding to a quantitative attribute for a particular region. This can help visualize data that is not proportional to region sizes.

3. Data and Task Abstraction

3.1 Datasets

Our World in Data provides publicly available datasets on the COVID-19 pandemic [9]. Specifically, we want to look at three datasets: Confirmed COVID-19 cases, reported vaccination rates and the stringency index.

The confirmed COVID-19 case data gives a daily update of the confirmed case count, the country and, if available, the province/region. We will take a 7-day average of the confirmed cases then translate that to the cases per 100,000 people in the region. If population data is not available for some regions, we will aggregate the neighboring regions to report on the total country instead.

Vaccination rates provide the reported number of people fully vacationed by region. We will convert this to the percentage of the region's population that is fully vacationed. Since we are only looking at the recent total, we do not need to average over any period of time.

The stringency index looks at the response policies regarding the COVID-19 pandemic. The Oxford Coronavirus Government Response Tracker (OxCGRT)[10] project calculates this stringency index using 20 indicators divided into 5 categories: Containment and closure policies, Economic policies, Health system policies, Vaccination policies, and Miscellaneous policies. The final stringency index is a number between 0 and 100 where 100 is the strictest. This index is only by country and does not look at individual regions.

3.2 Tasks

The main tasks we hope to accomplish will involve visualizing the datasets listed above. Some tasks we would like to achieve with our implementation of the necklace map algorithm are:

- Discovering trends by comparing symbols on different necklaces. e.g. Is there a noticeable pattern in the case number necklace and the stringency index necklace?
- Look up a specific country's data. e.g. What are the current COVID-19 case numbers in Canada?
- Compare different geographic areas: e.g. How does the vaccination rate necklace of Europe compare to the vaccination rate necklace of North America?

4. Solution

In order to implement the Necklace map algorithm, it is vital that we select the appropriate programming language and packages. Based on the recommendations and our preliminary research, we have decided to choose one of the following combinations.

- Python + Altair: Python is a language that all of our members are fairly familiar with. However, we have not used the Altair package before, hence, we are uncertain whether it has the desirable functions.
- JavaScript + D3: This is one of the recommended tools. After studying the documentations and sample projects, it became clear to us that this is a very powerful tool and can satisfy the need for this project. However, none of our members has extensive experience with it. Combining this with the steep learning curve, we are cautious about committing to this approach.
- Java/Processing + Unfolding: The original paper is implemented in Java. Although the specific package is not specified, we suspect it utilizes Processing and/or Unfolding. We have no doubt in its capabilities, but same as JavaScript and D3, the downside is that we have limited experience with it.

As of now, deeper investigation on these tools and their capabilities is needed. We also recognize the sunk cost fallacy: If it is determined that certain critical features cannot be achieved with the current tool, we would consider switching to the other options.

5. Scenario

Since the project is still in its early stage, there are no results to show. However, we would like to describe the ideal final program and how the user would interact with the tool. It is possible that we cannot realize all the features described below given the time constraints, nonetheless we aim to have the users explore the dataset with the following steps:

- Upon starting the software, a map of all countries in the world appears, all in grey to indicate unselected status. This map should allow zooming in and out, in addition to translational movement.
- The user would then click to select the countries and a necklace visualizing the data of interest, such as COVID-19 case numbers of the countries, would pop up along with the clicks.
- All selected countries are color coded corresponding to its symbol color on the necklace. If the user wants to unselect certain countries, they would simply click those countries again.

Some additional features include the ability to select countries by searching for it with text, and a drop-down menu to specify what data of interest is, whether it is COVID-19 case numbers or stringency index of response policies.

6. Milestones and Timeline

Weeks	Tasks and Descriptions
W1	• **Project Proposal (Oct 21 noon)**

W2	• Literature Research
	    ○ Other map visualization techniques
	    ○ Capabilities and learning curves of multiple tools
	• Data Preparation
	    ○ Clean and filter existing data https://ourworldindata.org/covid-stringency-index, https://ourworldindata.org/covid-cases, https://ourworldindata.org/covid-vaccinations
	• Basic Program Structure
	    ○ Design and implement the application front end
	    ○ Design the APIs and create the codebase
	    ○ Set up git repo if necessary

W3
- Geometric Map Visualization
    - Visualize the world map
    - Link database with the application

W4
- Basic Necklace Algorithm Implementation
    - Hard code fixed necklace first and implement the algorithm

W5
- **Project Updates (Nov 16 3pm)**
    - Prepare the slides and presentation
- **Peer Reviews (Nov 17 in class)**

W6
- **Post-update Meetings (Nov 24 & other times that week TBD)**
- Modification Based on Comments
    - Make necessary modifications and adjust plans based on reviews from the class and the comments from the meeting

W7
- Advanced Features
    - Design and Implement automatic generation of the necklaces (Potentially time consuming because this is not implemented in the original paper)

W8
- Advanced Features Cont.
    - Finish up previous features
    - Implement country search bar if time allows
- Performance Optimization
    - Latency optimization if time allows

W9
- **Final Presentation (Dec 15 2-6pm)**
- **Final Paper (Dec 17 8pm)**

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7. Reference

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