

THE 10TH WORKSHOP ON VISUAL ANALYTICS IN HEALTHCARE

Visual Analysis of Multi-scale Trends of COVID-19

Huan He*, Sijia Liu, Liwei Wang, Andrew Wen, Ming Huang, Yanshan Wang, Hongfang Liu**

Division of Digital Health Sciences, Department of Health Sciences Research, Mayo Clinic

* He.Huan@mayo.edu ** Liu.Hongfang@mayo.edu

Outline

- Background
- Task Analysis and Design Requirements
- Data Abstraction
- System Architecture
- Visual Designs
- Case Studies
- Discussion
- Summary

Background

• COVID-19

In 2019, a new coronavirus was identified as the cause of a disease outbreak. The virus is now known as the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2).

The disease it causes is called coronavirus disease 2019 (COVID-19). In March 2020, the World Health Organization (WHO) declared the COVID-19 outbreak a **pandemic**.



As the pandemic spreads, the public and researchers became more concerned about the potential trends of the COVID-19 spreading in their local communities.

Image source: https://www.mayoclinic.org/-/media/kcms/gbs/patient-consumer/images/2020/02/12/16/17/coronovirus-8col.jpg

Task Analysis – Evolving Needs

Show the data

Prototype system for monitoring the total cases in each county and state

- Choropleth map
- Line chart



3/09 03/10 03/11 03/12 03/13 03/14 03/15 03/16 03/17 03/18 03/19 03/20 03/21 03/22 03/23 03/24 03/25 03/25 03/27 03/28 03/29 03/30 03/31 04/01 04/02 04/03

The screenshot of the first prototype system showing the county-level distribution of the confirmed cases

Task Analysis – Evolving Needs

Show more data

Prototype system for showing more aspects of the regional situation

- New indicators
- More line charts



The screenshot of the second prototype system showing more indicators of a specific region

Task Analysis – Evolving Needs

Show more regions

Prototype system for combining both the regional and global situation

- Dashboard
- Regional panels



The screenshot of the third prototype system showing more regions for comparison

Task Analysis – Tasks and Design Requirements

- T.1 What is the **geographic distribution** of the COVID-19 pandemic?
- T.2 How does the regional COVID-19 pandemic change over time?
- T.3 What is the **regional difference** between COVID-19 outbreaks?



- R.1 Multi-scale exploration of regional COVID-19 pandemic state.
- R.2 Exploration of temporal trends of regional COVID-19 pandemic state.
- R.3 Exploration among different regions.
- R.4 Interactive exploration.

Data Abstraction

Indicators

• Case Doubling Time (CDT)

The number of days taken for the number of coronavirus cases to double.

• Cr7d100k

7-day smoothed average daily case rate per 100k capita

• RW_Cr7d100k

the ratio of this week's Cr7d100k comparing to the week before

CrRW Status

GREEN: Cr7d100k<15 and RW<1 for 7 days **RED**: Cr7d100k>30 or RW>1 for 7 days

ORANGE: everything else

$$CDT_{d} = 4 \times \frac{log(2)}{log(N_{d} + 0.5)/N_{d-4}}$$
$$Cr7d100k_{d} = \frac{1}{7} \times \frac{100,000}{Population_{region}} \times \sum_{i=d-7}^{d} n_{i}$$

 $1_{22}(\mathbf{2})$

$$RW_Cr7d100k_d = \frac{Cr7d100k_d}{Cr7d100k_{d-7}}$$



System Architecture – Data Pipeline

Data sources

- USAFacts
- COVID-19 Tracking Project
- CDC COVID Data Tracker
- Johns Hopkins Coronavavirus Resource Center
- Data watcher
- Data pre-processing
- Data calculation
- Output multi-scale regional JSON files
 - County-level
 - State-level
 - Country-level



System Architecture



¹ https://ohnlp.github.io/covid19tracking/
 ² https://www.mayoclinic.org/coronavirus-covid-19/map

Based on Vue.js, Plotly, Mapbox, and ECharts

Visual Design – Map View

Three maps



For 2020-11-12, US, (Population: 326,687,501).

 Cr7d100k:
 40.24 cases per 100k capita
 RW_Cr7d100k:
 1.32
 New cases:
 153,496

 Total cases:
 10,552,821
 Case Doubling Time:
 51.1 days
 Total death:
 242,901

 Death rate:
 2.30 %
 Total Cases / Population:
 3.2302 %
 Total Cases / Population:
 3.2302 %

For 2020-11-12, Minnesota, (Population: 5,639,632).

Cr7d100k: 93.55 cases per 100k capita RW_Cr7d100k: 1.64 Pandemic Vulnerability Index: 0.45 (Median) New cases: 7,225 Total cases: 201,795 Case Doubling Time: 25.3 days Total death: 2,246 Death rate: 1.11% Total Cases / Population: 3.5782 %

State-level

For 2020-11-12, Olmsted, MN (Population: 151,436).

Cr7d100k: 43.87 cases per 100k capita RW_Cr7d100k: 0.97 Pandemic Vulnerability Index: 0.46 New cases: 0 Total cases: 4,395 Case Doubling Time: 65.4 days Total death: 29 Death rate: 0.66 % Total Cases / Population: 2.9022 %



Visual Design – Map View

- Color encoding
 - CrRW Status
 - CDT
 - Total Cases / Population
 - CDC PVI *
- Interactive designs
 - Hover and click events
 - Linked map

🚱 COVID-19 Trend | 🏶 Home | 🚳 MC HRR Case Rate Trends | 🥸 World Case Rate Trends | 🕱 MC HRR Case Doubling Time Trends | 🖗 About



For 2020-11-12, Russia, (Population: 144,478,050).

 Cr7d100k:
 14.24 cases per 100k capita
 RW_Cr7d100k:
 1.11
 New cases:
 21,333

 Total cases:
 1,843,678
 Case Doubling Time:
 60.0 days
 Total death:
 31,755

 Death rate:
 1.72 %
 Total Cases / Population:
 1.2761 %

For 2020-11-12, Arizona, (Population: 7,278,717).

 Cr7d100k:
 27.07 cases per 100k capita
 RW_Cr7d100k:
 1.34

 Pandemic Vulnerability Index:
 0.55 (Median)
 New cases:
 1,399

 Total cases:
 266,562
 Case Doubling Time:
 99.9 days

 Total death:
 6,240
 Death rate:
 2.34 %

 Total Cases / Population:
 3.6622 %





For 2020-11-12, Watonwan, MN (Population: 10,952)

Cr7d100k: 30 cases per 100k capita RW_Cr7d100k: 0.85 Pandemic Vulnerability Index: 0.42 New cases: 0 Total cases: 635 Case Doubling Time: 99.3 days Total death: 4 Death rate: 0.63 % Total Cases / Population: 5.7980 %

* The Pandemic Vulnerability Index (PVI) is an indicator which integrates baseline data on relevant community vulnerabilities with dynamic data on local infection rates and interventions <u>PMID: 32817964</u>. The data of PVI model are from <u>CDC COVID Data Tracker</u>.

Visual Design – Trend View

Trend chart

• How to show the changes of the multiple indicators over time intuitively?



- Combining line chart and area chart shows the pandemic
- Show the full history of the regional Cr7d100k, RW_7d100k, and CrRW status at the same time

Visual Design – Trend View

- Color encoding
 - CrRW status
- Interactive designs
 - · Linked with the map view
 - Hover events
 - All trend charts are linked



Visual Design – Region Summary View

Combined trend view and other regional information









L≥ RST/SEMM Mayo Tests Trend | ⊕ 9/3/2020 Total Tests → Total Tests → MN Pos.Rate Pos.Rate(%) 150.000 120.000 90.0000 90.0000 90.0000 90.0000 90.0000 90.0000 90.0000 90.0000 90.0000 90.0000 90.0000 90.0000 90.0000 90.0000 90.0000 90.0000 90.00000 90.0000 90.00000 90.00000 90.0

Case Study 1 – Geographical distribution

- January to February
 - a few counties on the west coast etc.
- March to May
 - Whole country
- June to August
 - South regions
- September to October
 - Spreading in north regions
- November to now
 - Centre and north regions



Case Study 2 – Temporal patterns

4-29

5-9

5-19

5-29

6-8

6-28

618

7-18

7-8

Second wave

7-28

• Overall stable: few states

2-19

2-9

2-29

3-10

3-20

3-30

4-9

First wave



10-6 10-16 10-26

11-5

Third wave

8-7

8-17

8-27

9-6

9-16

9-26

^{©2020} Mayo Foundation for Medical Education and Research | slide-17





• Third wave: October to now, a lot of states



©2020 Mayo Foundation for Medical Education and Research | slide-20

• Third wave: October to now, a lot of states



©2020 Mayo Foundation for Medical Education and Research | slide-21

• Third wave: October to now, a lot of states



©2020 Mayo Foundation for Medical Education and Research | slide-22

Discussion

- CDT is sensitive in early stage
 - Low CDT indicates potential outbreak, but high CDT doesn't mean it's safe



CrRW status

- Sensitive to the RW_Cr7d100k
- Thresholds may need to be adjusted



Summary

- CrRW status for representing the current status of the pandemic as well as recent trends
- Trend chart design and other views for analyzing the regional pandemic
- Two case studies that show the distribution and the waves

Stay healthy, stay safe :) Thank you for watching!

Questions? <u>He.Huan@mayo.edu</u> Liu.Hongfang@mayo.edu

Source code and online live demo: https://ohnlp.github.io/covid19tracking/

