USING A CUSTOM WEB APPLICATION TO BETTER TRACK THE COVID-19 PANDEMIC

Improving the John Hopkins U.S. Map Dashboard

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Introduction

Site Launch and Impact

From the beginning of the COVID-19 pandemic, the Johns Hopkins University (JHU) Coronavirus Resource Center served as a valuable resource to news outlets, governments and individuals around the world. It informed policy decisions and helped inform individuals when the virus was spreading near them (Korn, 2020). In March 2020, it became clear that the virus was beginning to spread across the US. The impact of the virus varied between counties across the US, as did the policy decisions to combat the spread. Policy makers, journalists and the general public were interested to know the COVID-19 statistics of their county, compared to other counties in the US, to better understand their situation and how to effectively respond to it. JHU's US Dashboard was established in April 2020, focusing on the county-level data scraped from over 3,100 counties across various public health department websites. This dashboard uses Esri's off-the-shelf ArcGIS Dashboards technology, which allows for easy, code-free generation of a fully functioning dashboard web application (Cruickshank, 2020; Johns Hopkins Coronavirus Resource Center, 2020). I joined the team a few months later and became the manager of the US Map, and all future updates/maintenance to it.

Limitations

As the pandemic progressed, new web maps were continually added to it along with more data being added to the overall time series. There was a noticeable drawback to this application: it ran slowly, and we were limited in the number of web maps we could attach to it without it slowing down too much or crashing. The Dashboard tool was very useful in propping up a web application quickly with no coding experience but was ultimately not as efficient as it should have been in the long term.

The existing design caused a lot of performance issues. Each tab showing different types of COVID-19 data were separate web maps, and when the dashboard loaded the application tried

to load every web map at once. Therefore, it loaded slowly, and even crashed in some cases. Finally, a non-technical limitation our team faced was needing to coordinate with Esri's team, who handles a lot of the technical aspects of the front end of the dashboard. Ultimately, many of these limitations were a result of needing to release data to the public as quickly as possible, because things moved fast during the pandemic, and it was more important to get useful quality data to the public than it was to have the most efficient UX/UI. I think that having a better UX would improve the general public's ability to consume the data and cause less confusion on how to find and interpret information.

The benefit of using an off-the-shelf product was immense at the beginning of the pandemic. This was when data was moving fast, and decisions needed to be made. I believe pivoting to a custom web application could have improved the longevity of this project and reduced the limitations outlined in this section.

Other Dashboards and Data Hubs

Most state Departments of Public Health (DPH) throughout the pandemic have set up their own dashboards and data hubs to track COVID-19 in their respective home states. In most cases, off-the-shelf products such as Tableau, Microsoft Power BI, and ArcGIS Dashboards were used. This was likely for the cost savings and speed it takes to set up. For example, Wyoming's DPH used Tableau, West Virginia's DPH used Microsoft Power BI, and Alabama's DPH used ArcGIS Dashboards (Alabama Department of Public Health, 2021; West Virginia Department of Health and Human Resources, 2021; Wyoming Department of Health, 2021).

Other states only provided the data in comma separated plain text format, or in Rhode Island's case simply a Google Sheets document (Rhode Island Department of Health, 2021). There were some states that created customized web apps/websites to report their COVID-19 data, such as Utah. Their site had an embedded map showing county-level information for their state built with Leaflet (Utah Department of Health, 2021). From what I saw, most states did not use a custom-built geospatial web application.

Objectives

For this project, my goal was to create a customized web application to fulfill the same purpose as the US Map Dashboard but with specific improvements using lessons learned from one year of operating the existing US Map dashboard. This application could serve as a template for future projects when providing spatial data to the public, expeditiously, is important.

The dashboard in its current form relies on Esri's off-the-shelf ArcGIS Dashboards product, which has certain design limitations. We were only able to use the built-in widgets to show and filter their information. A customized web app opens the possibility to utilize custom-built HTML elements, with the freedom to place them anywhere and design them however is needed. The custom app would also allow for more freedom in the use of color and images, which would enable us more freedom in branding.

Design limitations also lead to making choices that would later decrease performance and usability. With no single-click button to switch between layers on a single web map, we decided to have different tabs accessing different web maps for each layer. An unchangeable issue with the dashboard was that when it opened, it would attempt to load every web map. This led to three distinct limitations. (1) We were limited in the number of maps we could use because only so many tabs could fit beneath the map window. Since users have different sized screens, we had to concede that some users would be stuck with a dropdown menu of the maps, which makes it harder for a lay user to see all the data options. (2) Every time a new map was added, the dashboard would take longer to load since it needs to load all maps before being responsive. On occasion, the entire dashboard would crash when we had too many maps. (3) One perceived benefit of using different web maps was that we'd be able to track which maps were more popular by comparing the view counts, but since all the maps loaded simultaneously, regardless of being accessed by a user, it was impossible to see those statistics.

The main goal of this project was to replicate the existing JHU US Map Dashboard using customizable opensource tools to make key changes that improve UX and performance. These

changes would give control of the dashboard to the developer to handle various issues such as speed, UX, and branding considerations, rather than being beholden to the limitations of an off-the-shelf product. Not only would a custom app reduce technical limitations, but also it would remove the need to coordinate with Esri consultants when we make changes to the UI or the data of the dashboard.

Methods

Data Acquisition

All the data used on the current US Map comes from publicly available sources, so I utilized those sources to produce my custom web application. For COVID-19 case and death data, I used the Center for Systems Science and Engineering at Johns Hopkins University datasets (Dong et al., 2020). To create population adjusted maps, I used population data from the American Community Survey 2019 5-year estimates (U.S. Census Bureau, 2020). For hospitalization data, I used the U.S. Department of Health and Human Services COVID-19 Reported Patient Impact and Hospital Capacity by Facility dataset, aggregated at the county level (U.S. Department of Health & Human Services, 2021).

One of the most important datasets was the geographical files. GeoJSON files were used instead of shapefiles to reduce the file size and greatly improve performance. I collected both county level and state level GeoJSON files to eventually be joined with COVID data on their unique FIPS codes. I ensured that the resolution was not too high to maintain good performance for the thousands of counties that would have their data visualized at once.

Data Cleaning and Processing

Much of the data I used was not in a readily visualizable format. Cleaning and processing were required to effectively display it. I did this work primarily using Python's pandas and GeoPandas packages. I joined the applicable data by FIPS code to the GeoJSON files and saved them to a

GitHub repository. When these files were updated with new data, the web application automatically picked up those changes since it is fed by those GeoJSON files.

Dashboard Development

I began my development by building a wireframe diagram of my vision for a production version of the application (Figure 1). I showed it to my peers at work, who also have a lot of experience working with and visualizing COVID-19 data, to get opinions on the UI and planned UX. I used JavaScript, HTML and CSS to design the application, and utilized the data produced by the Python script. I received assistance and advice from a coworker with experience with Leaflet and JavaScript. This web application ended up largely being developed using those two tools, along with the data processing tools mentioned in previous sections.

Figure 1. Wireframe prototype

Results

I successfully created a web application with assistance from a work colleague (Figure 2). The finished product is a Leaflet application which can load both state and county COVID-19 data quickly and effectively. In total, 16 data layers were added to the map, but more could be added with minimal impact to performance. The outcome is different from the wireframe because I focused on functionality over presentation. If given more time to work on this application, I would implement UI/UX improvements to combine the functionality and performance of my web application, with the design of the wireframe. Both the wireframe and the web application work in tandem to serve as a proof of concept for future events where tracking public health data is necessary.

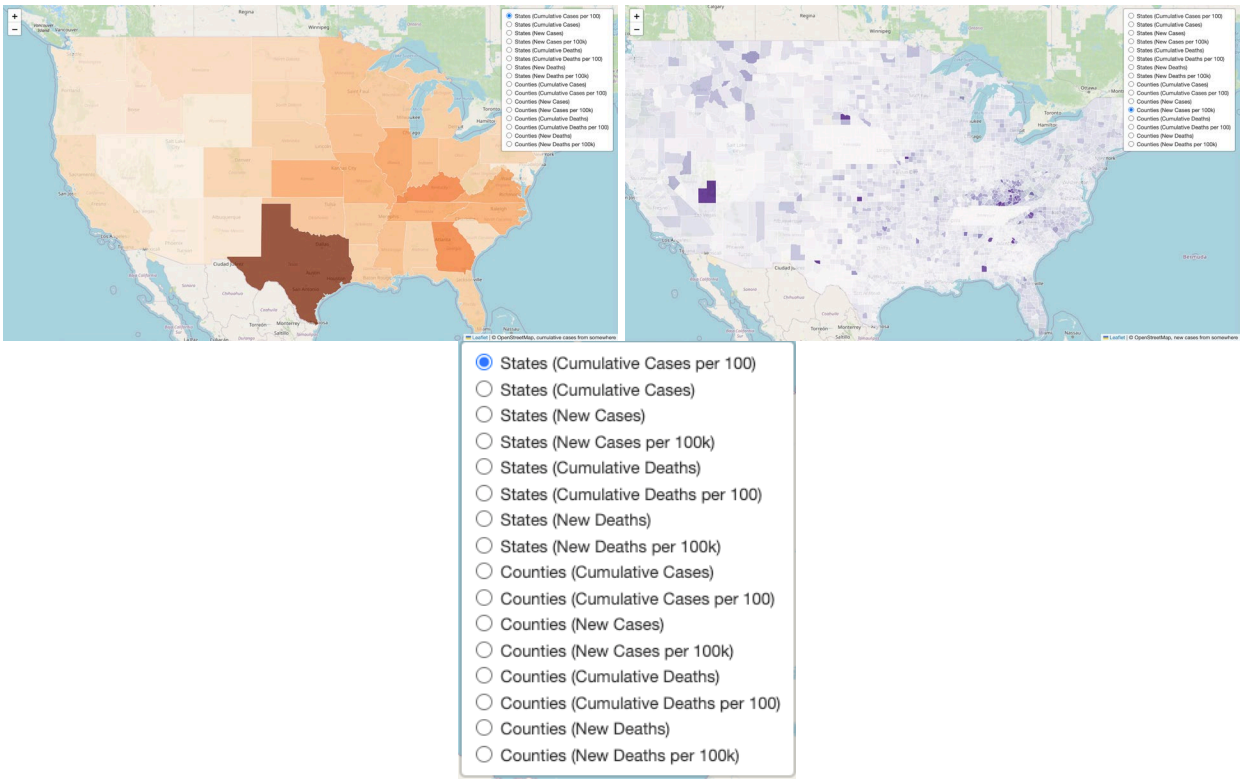

Figure 2. Screenshots from the Leaflet web application

Conclusion

There are benefits and detriments to using an off-the-shelf product such as Esri's ArcGIS Dashboards product. It allowed for quick setup of a dashboard web application with little to no code involved. At the time, this was the right decision, as COVID-19 data was brand new, rapidly changing and urgently needed visualization for decision making. After some time though, I believe pivoting to a web application such as the one I developed would have been a better decision for the longevity of the project. It would reduce reliance on a third-party vendor, Esri, to maintain the application, and it would improve performance as we add a plethora of new data. The web application I developed successfully replicated the JHU US Map Dashboard, replacing the existing tabs with layers which only get loaded when the user requests them. This change solved the main problem related to performance.

Though this project is a reproduction of an existing product, I believe improving upon the design now will proactively improve our ability to respond to future events where it is imperative to share aggregated public data availability at the national level. In my experience looking at various state public health department COVID-19 dashboards, I saw a lot of reliance on off-the-shelf products, but I think that showing the benefits of a custom-built application may inform my own organization along with other organizations of what's possible and could make them aware of the value of having a custom-built application. By proactively developing a custom web application that can be used as a template, organizations may remove the need to reactively purchase off-the-shelf products when visualization is needed. Both options have costs and benefits, but selecting the reactive option leads to limitations in the long term. The proactive option, while requiring more technical expertise, would lead to immense flexibility in the long term.

References

Alabama Department of Public Health. (2021). *Alabama covid19 information hub*. Retrieved August 19, 2021, from https://covid19.alabama.gov/

Cruickshank, S. (2020, April 14). *Johns Hopkins launches new U.S.-focused COVID-19 tracking map*. The Hub. https://hub.jhu.edu/2020/04/14/johns-hopkins-launches-us-coronavirus-tracking-map/

Bureau, U. C. (2020). *Census.gov*. Census.Gov. Retrieved August 19, 2021, from https://www.census.gov/en.html

Center for Systems Science and Engineering (CSSE) at Johns Hopkins University. (2021). *COVID-19 Data Repository*. GitHub. Retrieved August 19, 2021, from https://github.com/CSSEGISandData/COVID-19

Dong E, Du H, Gardner L. An interactive web-based dashboard to track COVID-19 in real time. Lancet Inf Dis. 20(5):533-534. doi: 10.1016/S1473-3099(20)30120-1

Johns Hopkins Coronavirus Resource Center. (2020). *Covid-19 united states cases by county*. Johns Hopkins Coronavirus Resource Center. https://coronavirus.jhu.edu/us-map

Korn, M. (2020, November 19). *The 100 best inventions of 2020: Johns Hopkins Coronavirus Resource Center*. Time; Time. Retrieved December 13, 2021, https://time.com/collection/best-inventions-2020/5911434/johns-hopkins-coronavirus-resource-center/

Rhode Island Department of Health. (2021). *Covid-19 rhode island data*. Google Docs. Retrieved August 19, 2021, from

https://docs.google.com/spreadsheets/d/1c2QrNMz8pIbYEKzMJL7Uh2dtThOJa2j1sSMwiDo5Gz4/edit

Utah Department of Health. (2021). *COVID-19 Data*. Retrieved August 19, 2021, from https://coronavirus.utah.gov/case-counts/

U.S. Department of Health & Human Services. (2021). *COVID-19 Reported Patient Impact and Hospital Capacity by Facility*. Retrieved August 19, 2021, from https://healthdata.gov/Hospital/COVID-19-Reported-Patient-Impact-and-Hospital-Capa/anag-cw7u

West Virginia Department of Health and Human Resources. (2021). *West Virginia COVID-19*. Retrieved August 19, 2021, from https://dhhr.wv.gov/COVID-19/Pages/default.aspx

Wyoming Department of Health. (2021). *Wyoming COVID-19 Data*. Retrieved August 19, 2021, from https://sites.google.com/wyo.gov/covid-19/home

Code Sharing

For access to source code of the redesigned US COVID Dashboard, please contact Adam Lee for access at adamn1994@gmail.com and navigate to https://github.com/alee722/us_covid_map_redesign/tree/leaflet