Earthquake Visualization Application

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ABSTRACT

In this paper, we describe the Earthquake Visualization web map application. This tool build on open source software, including Carto, JS Bin and Leaflet.js. By using this application, user can view all the earthquake spots on different base maps. Application also allow users to add more than just earthquake layer to the map (including tsunami and volcano eruption data). All the spots show on the map are clickable, and the Time range selection bar on the bottom of the map can provide heat map.

Categories and Subject Descriptors

H.2.8 [Database Application]: Spatial databases and GIS

Keywords

Earthquake, tsunami, volcano, hazard, leaflet, open source, web mapping, JavaScript.

1. INTRODUCTION

We usually consider the ground to be solid and stable, however, earthquake happens a lot, thousands of small tremors occur every day. Countless lives were taken by earthquake. Because public only report large earthquakes, also due to the natural hazards have low density of the occurrence comparing to man-made events, people can hardly have a whole picture about the pattern of earthquake distribution.

We were told that tectonic movement is usually the reason for causing earthquake, one of the main objective of this work is to let users visually perceive the correlation of these two. Earthquake Visualization Application is completely build on open source software. Within the application, user will be able to manipulate the data shows on the map as well.

The report mainly contains five parts. Section 2 give a brief introduction about the hazard datasets used for display. Section 3 is about the backend architecture that support the whole web application. The essence of this report is in section 4, which includes a detailed introduction about the frontend and user interface. In section 5, we discussed our future enhancement, including what can be expected for our future application release.

2. HAZARD DATA

Datasets for this application including Earthquake Data, Tsunami Data and Volcano Eruptions Data were all from National Oceanic and Atmospheric Administration (NOAA). NOAA is an American scientific agency within the United States Department of Commerce focused on the conditions and atmosphere. And the structure of NOAA includes national weather services and national ocean services [1].

The original data range from more than 4000 years ago to year 2016. Datasets include some important attribute such as location name, coordinates, damage degree, hazard duration, etc. After convert the data to csv format and clean up the data, we maintained 3,439 records for earthquake events, 1,234 records for tsunami events, and 654 records for volcano eruptions from year 1900. We keep data only in this time range for two reasons. One is that some old data may not complete, in some years, there are only one earthquake event recorded or even not records. The second reason is that people some time do not have much emotional resonance for things happened too long ago.

In current version of Earthquake Visualization Application, most of the operation are focus on earthquake dataset. Tsunami and volcano eruption datasets were only used as earthquake related events data, which mainly help users to understand the correlation between earthquake and other hazards.

3. ARCHITECTURE

On the bottom part of this application is the database, all the spots, all the information shows on the browser for our users come from this area. To neatly store all the data, Carto is well implemented. Carto is an open source software as a service cloud computing platform.

Usually, in a web-based GIS application, there are at least two components besides frontend, database and server. Database for storing data and the server for connecting the database with browser. Carto does both, it provides GIS and web mapping tools for display in a web browser, which make the backstage of our application well-aligned and easy to handle.

Loading data by simply drag the CSV file into Carto. When query is required, use a link that contain the Structured Query Language (SQL) to obtain data from database, for example:

http://jingchaoyy.carto.com/api/v2/sql?format=GeoJSON&q=SELECT * FROM tsunami WHERE year >=1900

The first part of the link includes the application program interface (API) of Carto, and will allow the browser trace back to the database. The second part starting from SELECT is the normal SQL. This whole link will get the user result based on different SQL. The link above means getting all the tsunami data after year 1900. The returned data stored in GeoJson file.

```
$.getJSON(tsunami, function(cartodbdata) {
    var tsunamilayer = L.geoJson(cartodbdata, {
        onEachFeature: function(feature, layer) {
            layer.bindPopup("<h2>" + feature.properties.location_name + "</h2>");
        }
    }).addTo(tsunamiGoup);
});
```

Browser will read though the file and find its target based on the rules written in JavaScript, then all the spots will show on the map.

4. USER WEB MAP INTERFACE

The web user interface is the most important part of this Earthquake Visualization Application. User use this interface to view and manipulate the data. This whole application was developed in JavaScript with Leaflet API for the mapping capabilities. The D3 JavaScript library is used on the Brush function for Time Range Selection (TRS) Bar. There will be four small sessions for introducing the user interface (UI), letting users understand what to expect from the application, and getting a rough idea about how to use the application.

4.1 OVER VIEW

The figure below shows the initial UI for this web application. This UI allow user to visualize the Earthquake data and the data for tsunamis and volcano eruptions. When first open this application, map zoom and focus on California, with base map World Imagery. Each small circle stands for one earthquake event. Different color means different magnitude, range from one to nine using color from yellow to red. All the circle on the map are clickable, and after each click, a popup will list a little more information about this specific event. Take the one on Figure 1 as an example, the popup shows this earthquake event occurs in Santa Barbara, California in year 1925. The damage level is 3 (in the database, damage level range from 1 - 4), and magnitude is 6.8. All these data are grab from Carto using the method in section 3.

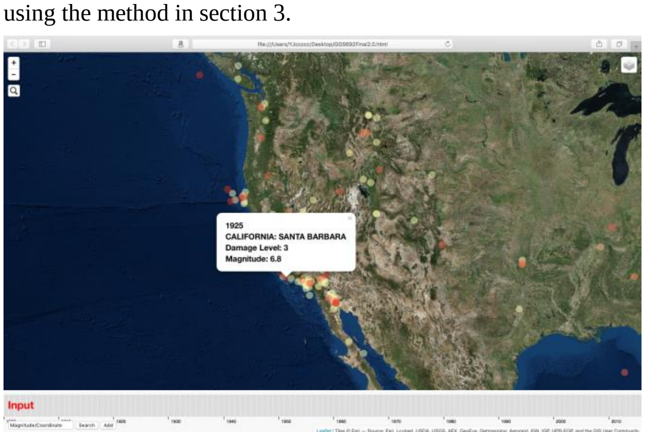


Figure 1. Screenshot of the Earthquake Visualization App showing the initial map view for California area

On the top left of the map, there are three buttons for zooming. Using the button with "+" and "-" symbol to zoom in and out. The one with magnifier icon called BoxZoom, which is a leaflet plugin. The main job for the BoxZoom is let the user zoom to a specific area they would like to view by click and drag the mouse on the map to rectangular select the place. On the top left of the map, there is a Layer Control panel. The panel will let the user know which base map they were viewing and which layer are turned on and shows on the map. User can also click to switch between base maps and choose different layers to add to the map. In the bottom left corner, there is one search field with two buttons. The test field will input numbers for magnitude or for coordinates. The search button will put earthquake events on the map based on the magnitude number put in the text field while the add button will put a marker for the location if the input is a coordinate. More detailed information about this search file will be introduced in section 4.3.

4.2 CHANGE LAYERS

On figure 2, after changing the base map, all the earthquake on the map are easier to observe. The main reason for choosing this base map with light colors is to separate the hazard events layer from the background base map. In contrary, the one named world imagery show on the figure 1 is more focus on the earth surface structures so that the users can obtain some basic land cover information of the area they selected. Looking at the whole planet, how earthquake related to the tectonic movement start to become obvious. Almost all the earthquake occurs near the edge of tectonic plate. In other words, the circle almost draws the plate boundaries on the map. If the user switch back to the World Imagery base map and zoom in to a smaller area like we displayed in figure 1, they will be able to find how earthquakes are distributed.

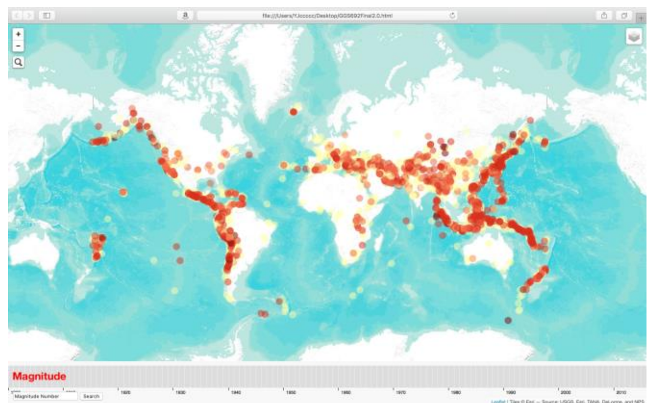


Figure 2. Screenshot shows the whole planet with all the earthquake events

To view not only the earthquake events, but also earthquake related events, simply move the mouse to the top right corner, click to check the Volcano Eruption and Tsunami Event. Since volcano eruptions can sometimes cause earthquakes, and if an earthquake occurs in the ocean, it can push up powerful waves known as tsunami, showing all three might help user to observe the relationships of their distribution [2][3]. After checking the layers to view on the map, use the BoxZoom tool to zoom to a specific area. Figure 3 below is an example displaying the distribution of all the three hazards in Indonesia area. Indonesia is a country located on the junction area of Eurasian Plate, Pacific Plate and Australian Plate, which make this area has the most unstable earth crust structure. On the image, circles, blue triangles and red squares are stand for earthquake, tsunami and volcanos respectively. Users can always tell which event they are looking at due to the tsunami icons have wave symbol on the markers and the volcano icons have volcano symbol. From the image, almost all the earthquake icons are covered by tsunami icons. It seems earthquake in this sea area might have impacts on the tsunami event. User can always click on the marker and find more information, such as time, to help them understand the data.

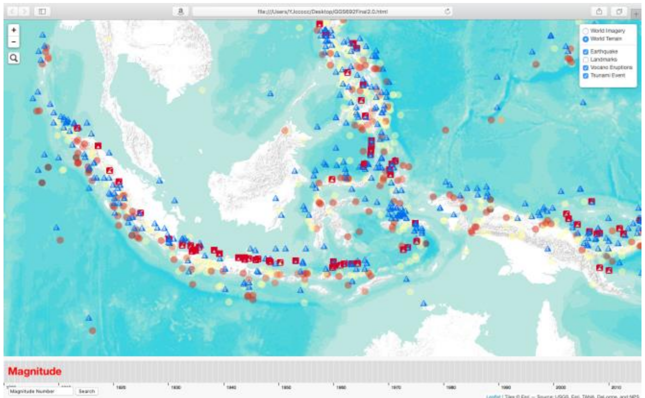


Figure 3. Screenshot shows the Indonesia area with earthquake, tsunami and volcano eruption events

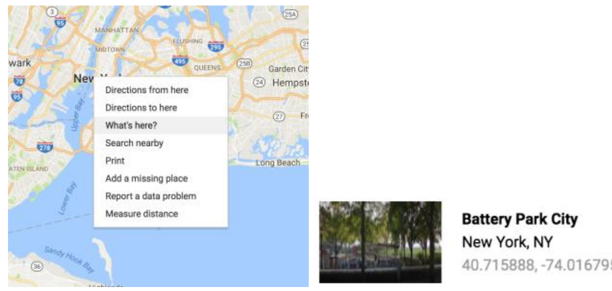
4.3 USING SEARCH FIELD

The search field will let user input the magnitude of earthquakes and search for the result. It also allows user to add their own markers to the map by input coordinates and click add button. Magnitude is a very important concept for measuring the power of an earthquake, it is the energy that the earthquake releases. Each magnitude is 33 times more powerful than the last, which means an earthquake with magnitude 7 is 33 times more powerful than an earthquake with magnitude 6 [4].

Figure 4. Screenshot shows the earthquake events with magnitude larger than 8

Zoom out to view the whole planet, turn off all the layers to avoid the icon overlapping. In the search field, input a number (usually range from 0 to 9), and click search. The earthquakes with magnitude higher than the number you input will show on the map with an earthquake icon in brown color. According to United States Geological Survey (USGS), the 1964 Chile Earthquake is the largest earthquakes in the world since 1900 [5]. As seen on the image above, the search function easily narrows the number of spots for user to locate the earthquake they want to find on the map. Click the icon, popup will list the time, location, damage level and magnitude of the earthquake.

How to use the search bar for adding makers to the map? The first step is to get the coordinate for the location. Open google map and search New York city as an example. Right click and select What's here? Google will provide you the coordinate. Copy and paste this coordinate to the text field. If users decide to obtain the coordinate from other sources, remember to keep the latitude at the first place, put a comma, then longitude.



After open landmarks layer from the control panel, and click add button, map will automatically zoom to the search location, and a new marker looks like a house will be displayed on the map. For the current version of our application, always input one coordinate at a time.

4.4 HEAT MAP

One of the most important feature of this Earthquake Visualization Application is that users have the power to create heat map themselves and show the result on the map. Focus on the bottom part of the map, there is a Time Range Selection (TRS) bar labeled within year from 1900 to 2010. Each year shows on the TRS bar has a one-decade gap from the last year. And all the small intervals between each number indicate one year. The total time range displayed on the TRS bar is from year 1900 to 2016. D3.js were implemented for this TRS bar. Each time when a user selects a time range, functions in D3 JavaScript library will filter the earthquake data, then use the new data collection to replace the old data and show them on the map. Before using this function, we suggest user to turn off all other layers first. In this way, the resulting heat map would look clean and clear. User can still add other layer back to compare the distribution.

Under normal circumstance, each event will represent itself on the map only once. Since natural hazards are not appear as frequently as man-made events like homicides, heat map will not have a decent reflect of the earthquakes distribution. We increased the weight of each earthquake events by 50 times, which means all the results provided by heat map are 50 times magnified. In this case, different colors on the heat map are only meaningful when comparing with each other.

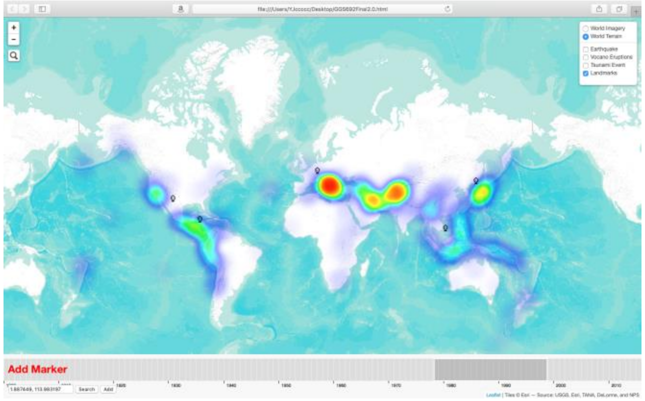


Figure 5. Screenshot of the Earthquake Visualization App showing the example of a heat map with time range from year 1978 to 1999

Using heat map, users can easily see the whole picture about the distribution of earthquakes in their selected time range. The density of the earthquake events grows when the color change from purple to red. In figure 5, areas close to Italy are the most earthquakes clustered. Under this time range, area near Japan, Caribbean Sea, Tajikistan and Indonesia are also had more earthquakes than other places on earth. Click and hold the shaded rectangular box, then slid it on the TRS bar, user can view the heat map change within the same time length but for different years. If user wants to only focus on some specific area. Using the search field introduced in section 4.3, add a maker by input the location coordinate, and you will see how the heat map change around the marker.

5. FUTURE ENHANCEMENTS

The application introduced in this report is the first iteration, some of the features still need improvements. In the future release, operation experience will be more user friendly. TRS bar will let user to choose which dataset for creating heat maps, or even select multiple datasets to show the correlation. The search bar should enable user to input a location name instead of using coordinates. Adding functions to the application such as allowing user to download the csv table based on their magnitude selection. Letting user to insert earthquake they observed will also be an important function, so that the map is real-time update. This application is very basic for now. Allowing user to accomplish all their ideas with the map is always the primary objective.

6. REFERENCES

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[3] http://volcano.oregonstate.edu/how-are-volcanoes-and-earthquakes-related

[4] https://www.youtube.com/watch?v=yNN7eDXzlMo

[5] https://earthquake.usgs.gov/earthquakes/world/10_largest_world.php