1 Introduction

The aim of the visualization is to create awareness among the people related to CO2 Emission by various countries of world. The report discusses the visualization process followed, and problem faced during the implementation. It contains the steps from analysing the dataset to construction of visualization tasks. The "CO2 Emissions from Fossil Fuels since 1751, By Nation" dataset is used for the task. The dataset is present in datahub.io and it is prepared by Carbon Dioxide Information Analysis Center.

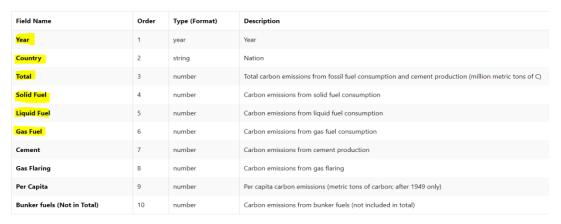The dataset contains the Country wise CO2 Emissions from various fossil-fuels from 1751 to 2014.

Field Name	Order	Type (Format)	Description
Year	1	year	Year
Country	2	string	Nation
Total	3	number	Total carbon emissions from fossil fuel consumption and cement production (million metric tons of C)
Solid Fuel	4	number	Carbon emissions from solid fuel consumption
Liquid Fuel	5	number	Carbon emissions from liquid fuel consumption
Gas Fuel	6	number	Carbon emissions from gas fuel consumption
Cement	7	number	Carbon emissions from cement production
Gas Flaring	8	number	Carbon emissions from gas flaring
Per Capita	9	number	Per capita carbon emissions (metric tons of carbon; after 1949 only)
Bunker fuels (Not in Total)	10	number	Carbon emissions from bunker fuels (not included in total)

Figure 1: Description of "CO2 Emissions from Fossil Fuels since 1751, By Nation" dataset

2 Description

I have implemented 3 visualization to understand the CO2 Emission by various nations.

2.1 Heat Map of CO2 Emission by Nation

The heat map is implemented in Tableau Software. The objective is to visualize the variation in CO2 emission of various countries from 1751 to 2014.

- Initially, I selected the **metrics** for the visualization i.e. '*Year*', '*Country*', and '*Total*'(total CO2 emission).
- The 'total' metric, containing total co2 emission in a particular year, is an Ordered data, whereas 'Location' column, obtained from datahub.io, is of Quantitative data type. The mapping of Location column is performed based on country name. The country name is nominal in nature.
- After identifying of data type, I found the suitable **visualization task** for the measurement. The country can be identified based on location. Moreover, the goal is to compare the co2 emission of various countries over the course to time.
- I decided to use the heat map showing the total co2 emission by different nations.
- In the heat map, I used Brightness as **encoding** channel to illustrate the variation in co2 emission in the different part of the world.
- The map contains the animation, which does the binning of 30 years. That means the map shows the variation in co2 emission every 30 years starting from 1751.

2.2 Comparison of Top 5 Country's CO2 Emission in different form

The idea is to identify the top 5 countries who spread maximum pollution by CO2 emission since 1751. Later, I thought of understanding the trend and comparing these 5 countries over 263 years starting from 1751. The comparison was performed on co2 emission by different "category of fossil fuel" (solid/liquid/gas). This visualization was also implemented in **Tableau** software with animation.

- For this work, I selected 'total co2 emission', and other attributes based on the type of fossil fuel i.e. 'solid fossil', 'liquid fossil', and 'gas fossil'. These measurements are *quantitative* in nature.
- The data of various countries (from 1751-2014) is aggregated to find the top 5 nation which emitted the maximum co2. These are USA, UK, China, Japan, and Russia (USSR). The list of 5 nation is of 'Ordinal' **data type**.
- This visualization is of 'Consumer' type, where the **task** was to create cluster of top 5 nation and comparing their co2 emission since 1751 as well as co2 emission from the various fossil fuel.
- The colour channel was used to illustrate the difference in co2 emission categoried into 3 types of fossil fuel. Moreover, the size **encoding** channel shows the amount of CO2 emitted by the category.

2.3 Top 10 countries with maximum CO2 Emission after 3rd Industrial Revolution

After implementing the above 2 graphs, I saw spike in CO2 emission in 19th Century and after 1950s. I was curious to know the reason and therefore, I read history channel article [1] and paper [2], which highlighted Industrial revolution to be the major cause of the increase in CO2 emission. Therefore, I created the 3rd visualization showing top 10 countries which emitted highest CO2 after 3rd Industrial Revolution.

- In this task, I used **Java Script** and **amcharts** library [3] [4] for the implementation.
- I started with data pre-processing by filtering the data of all countries based on time i.e. extracting the data after 1969 till 2014.
- Then, I checked the missing value in 'total' column. There were few countries with missing data for certain years. Therefore, I took the average and replaced the null values with the average.
- After pre-processing, the total CO2 emission of all countries was aggregated and the list of top 10 countries with highest emission was created.
- This list of top 10 countries is of ordinal data type. Other parameters like, CO2 emission from 3 fossil fuel categories (Solid/Liquid/Gas) were considered. These attributes were Quantitative **data type**.
- The primary visualization was to create a cluster of top 10 countries after Industrial Revolution, which was performed in previous step. Another **task** of the visualization is to compare the fossil fuel categories within these 10 nations and show them in map.
- For this, I decided to implement the Map Pie chart with the animation.
- Once the website loads, user sees a map with faded colouring on the top 10 countries. When your hover over the country area, the country name appears.
- When the user clicks on a country, a pie chart will open, showing the proportion of CO2 emission of 3 different categories of fossil fuel.
- The other **encoding** channel in this visualization are brightness, which changes on hover and orientation of pie chart.
- The project has been deployed and is live on: https://raviy0807.github.io/

3 Area of Improvement

The graph 3, have some issue in zooming out apart from this, I could have also tried to implement graph 1&2 with small binning size. Moreover, I could have visualized the fossil fuel categories with donut or stack chart

4 Learning from Module

- Identify the suitable chart based on the visualization task and data type.
- Developed the understanding of data visualization process.
- Introduced animation in the chart and their significance.

References

[1] "History.com," A&E Television Networks, 06 11 2009. [Online]. Available: https://www.history.com/topics/natural-disasters-and-environment/water-and-air-pollution. [Accessed 2019].

[2] J. C. S. H. C. P. C. F. Boutron, "Post-Industrial Revolution changes in large-scale atmospheric pollution of the northern hemisphere by heavy metals as documented in central Greenland snow and ice," in *American Geophysical Union.*, 1995.

[3] Amchart, "amchart," amchart , 2017. [Online]. Available: https://www.amcharts.com/docs/v4/.

[4] A. Demo, "Demo Archive," Amchart v4, [Online]. Available: https://www.amcharts.com/demos/#maps.