Meteorite Landings
CS 725/825, Fall 2017

Pratik Navale and Kamla Kant Tripathi
Department of Computer Science
Old Dominion University
Norfolk, VA 23529
{pnavale, ktripath}@cs.odu.edu

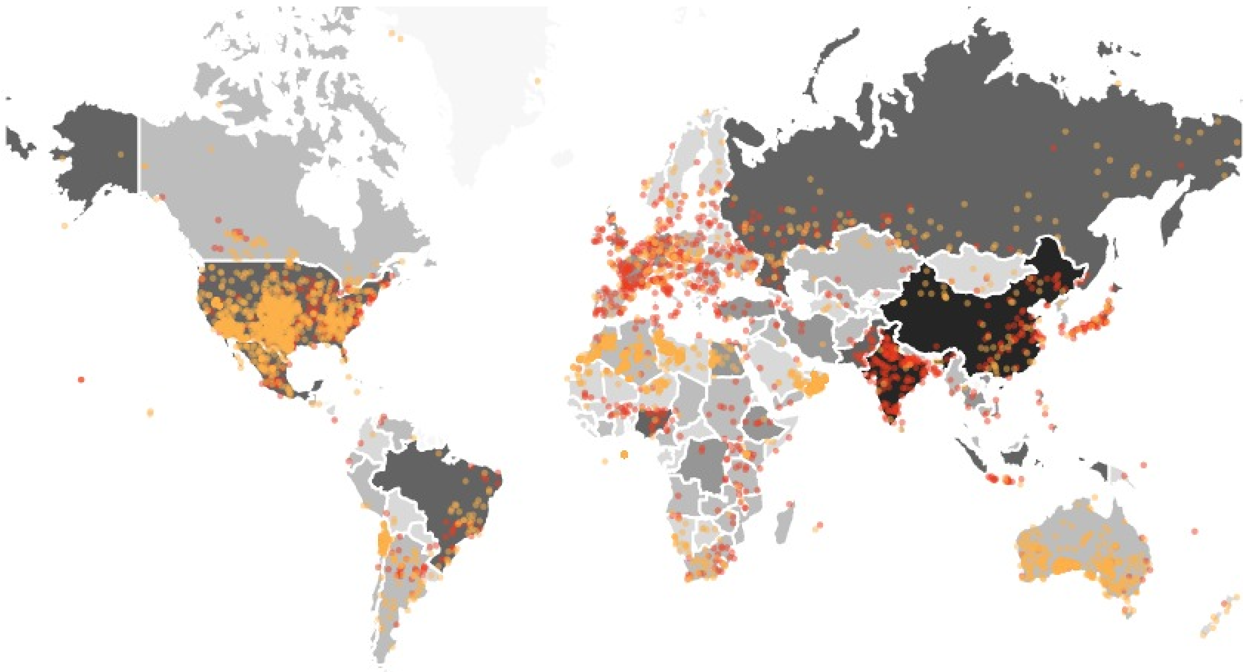

Fig. 1. Meteorite landings

Abstract—This work aims to visualize the meteorite landings on Earth based on their fall type - fell (meteorites that were witnessed during their fall) and found (meteorites that are discovered many years later). We first show the correlation between meteorite falls and world population distribution by providing an interactive world population choropleth map with all meteorite landing sites. Through an interactive line chart, a viewer can track the number of meteorites landings over the years. Cross-filtered bar and pie charts represent the number of meteorite landings and their proportion by fall type for each country.

1 Introduction

Meteorites landed on Earth can be classified as fell or found. Meteorites classified as fell are those that are collected soon after being witnessed live, whereas found meteorites are discovered many years later [1]. Our work is an attempt to analyze, through visualization, the recorded meteorite data of both fell and found meteorites through time and geography respectively.

2 Related Work

Meteorite data is of interest to meteoritics, research groups studying earth, planetary and space sciences, collectors and curators of meteorites. NASAs Open Data Portal [2] that hosts the comprehensive meteorite landings data set from The Meteoritical Society [3] has visualized the data set, leading to an open-ended exploration of the extent of the data set.

name	id	nametype	recclass	mass (g	fall	year	reclat	reclong	GeoLocation
Aachen	1	Valid	L5	21	Fell	1880	50.775000	6.083330	(50.775°, 6.08333°)
Aarhus	2	Valid	H6	720	Fell	1951	56.183330	10.233330	(56.18333°, 10.23333°)
Abee	6	Valid	EH4	107,000	Fell	1952	54.216670	-113.000000	(54.21667°, -113.0°)
Acapulco	10	Valid	Acapulcoite	1,914	Fell	1976	16.883330	-99.900000	(16.88333°, -99.9°)
Achiras	370	Valid	L6	780	Fell	1902	-33.166670	-64.950000	(-33.16667°, -64.95°)
Adhi Kot	379	Valid	EH4	4,239	Fell	1919	32.100000	71.800000	(32.1°, 71.8°)

Fig. 2. Tabular data set of meteorite landings [2]

3 Data

The Meteoritical Society [3] collects and records data of all known meteorites that fall on Earth from outer space. Data set for our work was downloaded from NASAs Open Data Portal [2], which hosts this meteorite landings data. The primary dataset contains 45.7K rows and 10 columns where each row is an entry for a specific meteorite.

Figure(2) is an excerpt of downloaded data set and Table(1) lists brief explanation of each attribute of the data set.

---

name: the name of the meteorite (typically a location, often modified with a number, year, composition, etc)

id: a unique identifier for the meteorite

nametype: one of: – ***valid:*** a typical meteorite – ***relict:*** a meteorite that has been highly degraded by the weather on Earth

recclass: the class of the meteorite; one of a large number of classes based on physical, chemical, and other characteristics

mass: the mass of the meteorite, in grams (g)

fall: whether the meteorite was seen falling, or discovered after its impact; one of: – Fell: the meteorite's fall was observed – Found: the meteorite's fall was not observed

year: the year the meteorite fell or found

reclat: the latitude of the meteorite's landing

reclong: the longitude of the meteorite's landing

GeoLocation: a parentheses-enclosed, comma-separated tuple that combines reclat and reclong

---

The data set had to be cleaned to eliminate blank fields of some of the attributes.

4 Visualization

Meteorite Landings Project (found at : http://www.cs.odu.edu/ pnavale/cs725/MeteoriteLandings/index.html) visualizes the meteorite landings data with emphasis on meteorite fall pattern over the years. Each chart is further explained in detail.

4.1 World map

All meteorites are encoded as points on a choropleth world map.

Layer-1

The choropleth world map illustrates the population of each country. The legend for the map explains the population of a particular country. Each country on the map can be clicked upon to zoom into that country to reveal a detailed view. Clicking again returns to the default view of the world map.

Layer-2

Each point is a meteorite landing that is color coded to illustrate its fall type (i.e. fell/found). When hovered over a point, more information pertaining to the highlighted meteorite appears that lists the name, id, nametype, class, mass, fall type and year. This layer can be toggled to show/hide meteorite points on the choropleth world map by clicking on Show/hide meteorites.

This chart was implemented using the d3v4 version of Javascript library by Mike Bostock.

4.2 Brushable Timeseries Chart

The overview time series line chart encodes the number of meteorite landings over the years. This chart has the time range from 860 - 2013, which the time span of our data. Year, the x-axis was plotted against meteorite landings, the y-axis.. This chart incorporates context and focus with interactivity. The slider can be used to zoom in/out and pan across to show particular area of interest. When a user zooms in or out, the scale of x-axis changes appropriately.

This chart is implemented using the d3v4 version of Javascript library.

4.3 Fall Analysis

This visualization is a combination of two linked charts - a bar chart and a pie chart. For this chart, the meteorite landing data recognized by National History Museum was used.

Bar chart

This bar chart encodes the count of meteorite landings for various countries; count is given on top of each bar. The default view of this chart illustrates overall count (fell and found).

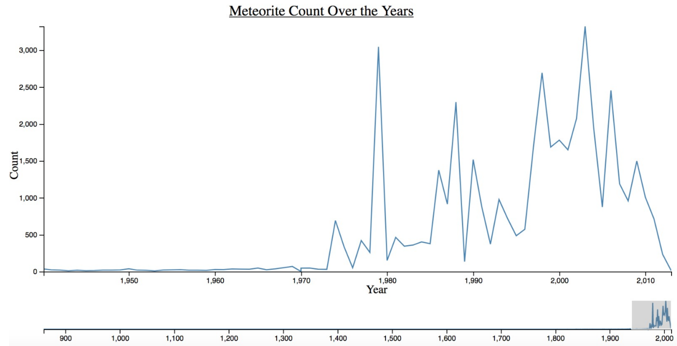

Fig. 3. Line chart of meteorite count over the years

4.4 Fall Analysis

Pie chart

The pie chart encodes number of meteorite landings by fall type (fell/found). A legend identifies the fall type, along with its count and percentage.

Interactivity of bar and pie chart

Hovering over a particular country item in the bar chart highlights the item and reflects its fall type in the pie chart. Also, hovering on a slice (fall type) in the pie chart reflects count (by fall type), with the appropriate highlight color in the bar chart.

This chart is implemented using the d3v4 version of Javascript library.

4.5 Design Decisions

We believe all the charts that are related put together in a single - view perspective help analyze our insight in the best possible way. It is a good practice to follow as it reduces the cognitive load of the viewer. Design decisions made for each chart are given below.

4.5.1 World map

Layer-1

The meteorite landings span all across the world. We intend to view their distribution over the entire world demography. Mercator projection of a world map is used as it is well-suited for visualizing interactive world maps that can be zoomed seamlessly with little distortion. The color scheme we chose to encode world population is sequential and grayscale as the idea was to encode population intensity (single variate data), which is not our primary focus.

Layer-2

The mark chosen to encode each meteorite landing site is a point as it helps with specificity. To deal with overlapping/occlusion, the point - mark incorporates some transparency.

4.5.2 Time series line chart

A line chart is most suitable for visualizing temporal data to track changes over short and long periods of time. It is better than a bar chart as the sharp edges give a clear distinction between adjacent marks. As the data spans an enormous area of interest, and we wanted the viewer to be able to zoom into years of interest, we chose to incorporate zoom and pan features into the chart.

4.5.3 Interactive bar and pie chart

We chose to encode countries and their meteorite landings count in a bar chart as it best compares categorical attributes when plotted adjacent to each other. We sorted them in decreasing order of their total count.

To compare meteorite landing fall types, a pie chart was used as it is best for comparing proportions, especially when there are less attributes to compare.

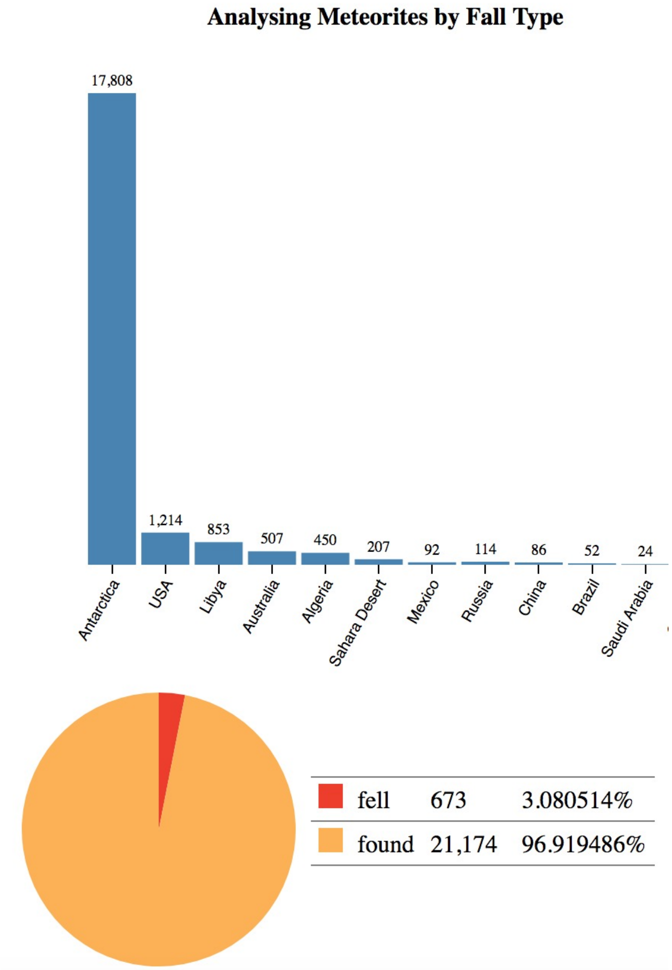

Fig. 4. Connected bar and pie chart by meteorite type

Interactivity was incorporated into both these charts to filter and compare what data the user is interested in viewing, and to avoid redundant charts.

Color A consistent color scheme was used to encode marks throughout the visualization. Both, fell and found meteorite types have respective colors encoded in the charts.

5 Analysis

What-Why-How framework

In this work, we have used the high-level framework of What-Why-How provided by Dr. Tamara Munzner, Department of Computer Science, University of British Columbia. We explain each component of this framework that was implemented in our project.

5.1 What - Dataset

The main CSV format data consists of 10 attributes and total 45,716 rows of data. This is cleaned in OpenRefine tool due to its huge size.

5.2 What - Derived

We represent three derived attributes:

1. The total meteorite landings per year.
2. The name of countries from meteorites geolocation.
3. Fell and found percent of meteorites in countries including Antarctica.

5.3 Why - Abstract Tasks

In this visualization, a user can do three main tasks- analyze, search, and query. In analyze task, a user can analyze the meteorite landings density with the world human population map. In search task, a user can lookup the meteorite landings points in a specific location. A user can also zoom the world map for a clear view of any individual point. In query, users can determine the correlation between year and total count of meteorite falls, which enables them to identify the year of highest meteorite fall in the line chart. Users can also identify the countrywise meteorite falls and compare the fell and found categories by count in the bar chart. Users can summarize the highest meteorite fell and found in any of the countries with percentages.

5.4 How - Encode

Primarily, whole visualization is arranged into three following major sections: 1. World map of meteorite landings. The background layer of world map with grey color luminance represents the human population of all geographic regions. The meteorite landings are mapped on this map by point features and seperate the fell and found category by red and orange colors respectively. Two statically positioned indexes for population density and meteorites detail is included in map view in which meteorite detail index dynamically changes by mouse over on meteorite points. Map view also consists a meteorite show/hide function to overview populations map and meteorite landing points separately.

2. Line chart for meteorite landings count. This chart shows the total meteorite landings for each year which is linked to a brushable bar.

3. Bar and pie chart for region wise meteorite landings. This chart is a bar chart consisting meteorite landings on a geographical region which is connected to a pie chart. The bar chart is differentiated in two colors: steelblue for the overall meteorite landings and blue to show the the fell and found ratio of an individual region through connected pie chart. The pie chart shows the overall fell and found ratio of meteorites by red and orange colors respectively.

5.5 How - Manipulate, Facet

To manipulate dataset, a user can select year range of interest in the line chart by using the slider-area chart associated with the line chart.Additionally, a user can pan and zoom the line chart area for the clear view. For facet, we apply overview and detail. Bar chart linked with pie chart gives the information of meteorite landings count of countries and Antarctica. On mouse over on fell and found section of pie chart gives the separate detail of fell and found meteorites of each country.

6 Insights

6.1 Meteorites Found

Most of the meteorites are found as a result of well coordinated scientific expeditions by research groups. Upon some background study, it was discerned that in the year 1976, Antarctic Meteorite Program was conceived, which held the first ever joint expedition to discover and collect meteorites in Antarctica [4]. Around 1995, meteorite collectors and nomads discovered meteorites in the Sahara desert [5]. Also, during the period 1999-2001, Russian and European field parties recovered many meteorites from the Arabian region [6]. An abrupt peak in the meteorite count for a particular span of time supports this claim.

6.2 Meteorites Fell

Most meteorites that were witnessed while their descent have been found in regions with more population. Countries in Asia such as India, China, Bangladesh and Japan are among most densely populated where the ratio of meteorites seen falling is more. This applies to European countries with high population density such as Netherlands, Belgium, France, Italy and the like. Also, more meteorites have been witnessed falling in the East Coast of United States where the population is considerably higher than any other region of the country.

7 Conclusions

A meteorite landings visualisation is developed to reveal temporal and geographic distribution of meteorite landing sites and analyze it based on their fall type - fell and found. From the meteorite landings visualisation, it can be assumed that the temporal and geographic distribution of meteorite landings is biased to events and demographic distribution of a particular region.

Final Thoughts

Developing a visualization of meteorite landings was interesting yet challenging. The challenges we face made us learn various project development skills. This project enhanced our skills of d3 along with web technologies. Initially, we faced a challenge to understand concepts and terminologies related to meteorites. Second, data handling due to its large size, different formats made us to struggle little bit more. Third, deployment of our project on GitLab was also a problem initially due to the space limit.

References

[1] www.space.com, 'Oldest Impact Crater on Earth Discovered', by OurAmazingPlanet Staff, 2012. [Online]. [Accessed: 19 - Nov - 2017].

[2] data.nasa.gov, 'NASA's Open Data Portal', Meteorite Landings, 2015. [Online]. [Accessed: 26 - Oct - 2017].

[3] meteoriticalsociety.org, 'The Meteoritical Society', International Society of Meteoritics and Planetary Science, 2002-2016. [Online]. [Accessed: 29 - Oct - 2017].

[4] mineralsciences.si.edu, 'Antarctic Meteorite Program', Smithsonian National Museum of Natural History. [Online]. [Accessed: 12 - Dec - 2017].

[5] Randy L. Korotev, 'Some Meteorite Statistics', 2017. [Online]. [Accessed: 12- Dec- 2017].

[6] A. J. T. Jull, J. Koblitz, B. Hofmann, I. A. Franchi, L., R. McHargue, and A. Shahab. Terrestrial Ages of Some Meteorites From Oman. 65th Annual Meteoritical Society Meeting (2002), University of California, LA.