Report of Visualization on Satellites Data *

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Abstract. This project visualizes satellites data on more than 1800 satellites from UCS Satellite Database via a responsive, interactive webpage with D3.js, Angular and Bootstrap to attract non-specialists' interest on satellites and space science.

Keywords: Visualization · D3.js · Angular · Satellites

1 Introduction

There are more than 1800 active satellites orbiting earth right now, taking pictures, broadcasting communication and navigation data, spying on every one living on the earth. However, despite the fact that people are being served and observed every day, actually not many are familiar with the topic and have the concept like what most satellites' uses and purposes are, how many satellites a given country have in orbit.

This visualization project, with three visualization parts, presents information about universal satellites in multi-dimensional aspects, in order to interest non-specialists and help them understand more about it.

2 Data

The data is from UCS Satellite Database [2]. It includes in-depth details on the 1,886 satellites currently orbiting Earth.

The database is updated roughly quarterly(The 4/30 2018 version is used for the project). The database contains 26 types of data for each satellite, including technical information like mass, launch date and orbit like apogee, perigee, as well as information on what the satellite is used for, owned by and so on. In order to use the data to draw charts and maps with D3 [6], many processes have been done to extract in-depth information and get the right format.

World map data from Nature Earth [4] is also used to project values of countries on the map. Mapshaper [5] is used to convert the data in shapefile into Geojson that D3 [6] can use.

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3 Approach

3.1 Design Considerations

Visualization is the process that designers encode data into visual representations and users decode them into understanding [1]. Our principal consideration is to turn massive, unreadable satellite data into expressive, clear visualizations, in order to help users understand more clearly about satellites orbiting the earth.

Multiple perspectives are considered. Also, each visualization are designed to have multiple layers, so that those who want to know more can get more information through interaction. What's more, different forms of visualization are be used, including maps, orbits simulation and several kinds of charts, to enhance audience's interest.

The page layout follows the story of a satellite: being launched from earth, working in the space and helping people with data. The page should be responsive to comply with the trend that many users use mobile devices nowadays. The page should also be interactive to give out information step by step.

3.2 Technical Considerations

The following techniques and tools are considered for the whole project: Javascript, D3.js [6], Angular, Bootstrap, HTML, CSS and Git.

The most important technique is D3.js for visualization. D3 provides many functions for visualization, including layouts, scale, axes, transition, map and so on.

Bootstrap helps when some common and satisfactory style and functions like colored and styled buttons are applied, so that not much time would be used on that. Also it helps with responsive page.

Angular is used for consistent development and maintenance. The project also can benefit from Angular because it can compile the whole project to achieve better speed.

Git is included for collaborative development.

3.3 Development

Main Development The main development is divided into 3 parts, since the page is mainly divided into three different visualization parts.

The first part is "On Earth" using d3 map. Geojson mentioned above is used along with D3 to draw the map. The accumulated number of satellites of countries and launch sites each year is used to draw the choropleth and symbol proportional map. A slider is developed to let user adjust time.

The second part is "in space", a dot map of satellite distribution. Every satellite is projected on their orbits as a circle using perigee as "r" and a random number between 0 to π to decide "cx" and "cy" on the page. Zoom-in and out function is developed with different scale and animation between each state is smooth. Each satellite can be colored by country/purpose/user based on

user choice. Meanwhile a stacked bar chart with mouse-over tooltip is developed showing detailed information

The third part is interactive charts using D3 layouts.

Common features in the project include responsive via Bootstrap, color scheme via well designed D3 color scheme, axes, and animated transitions via D3 transition function.

Extra Development Other than main parts, cover and navigator are also developed. The cover is basically an introduction, with a start button to jump to next section. The navigator contains four buttons to navigate the user to four parts of the page, and is fixed on top of the page to help user navigate through the page easily.

3.4 Evaluation

The team conducted this project based on well-thought design, enough skill set and own interest. With the visualization completed, the team believes the data about satellites can be interesting to non-specialists and help people understand more. The team tested every function to make sure it worked as planed.

4 System

4.1 Cover Page and navigator

The cover mainly includes the project name, introduction, background picture and navigator. The navigator is fixed on top of the page where-ever the audience has scrolled-down in the whole page.

4.2 First Visualization Part

The first visualization part presents a world map with a time slider. It is essentially a choropleth combined with proportional symbol map. The choropleth part shows the number of satellites owned by a country. The proportional symbol map part shows number of satellites launched by a launch site, as shown in Fig. 1. You can choose whether to show either choropleth or proportional symbol map or both, as shown in Fig. 2. Sliding the time slider shows users how data changes during a period of time.

4.3 Second Visualization Part

The second visualization part simulates satellites distribution in space, as shown in Fig. 3. "Choose Orbit" can be clicked to zoom-in and out to different orbits. Also, satellites can be colored by country/purpose/user by clicking "Color By". More detailed distribution on selected category will be given. Also a stacked bar

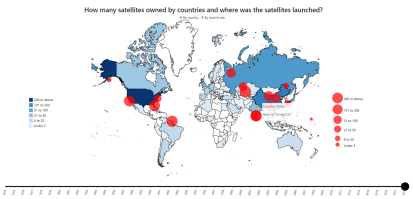

Fig. 1. Picture 1

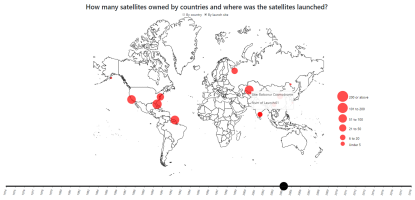

Fig. 2. Picture 2

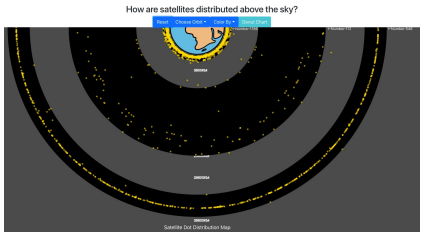

Fig. 3. Distrubition of Satellite

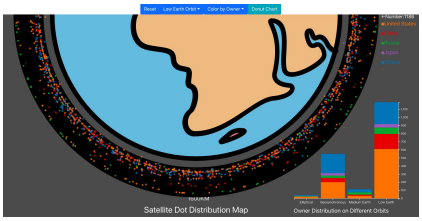

Fig. 4. Picture 2

chart with mouse-over tooltip can give you detailed number on each category on different orbits, as shown in Fig. 4.

Donut Chart is an experimental function that only works with Color by Owner, which can rearrange every satellite based on number proportion of countries. Lastly, Reset function can take you to origin state.

4.4 Third Visualization Part

The third visualization part tells more of the data. This part is a combination of interactive pie chart, bar chart and line chart. The pie chart shows detailed number of satellites owned by each country on different orbits, with tooltip and card showing detailed information, as shown in Fig.5. The bar chart shows detailed usage of several countries. The line chart shows trend of launch number along years. Then highlighting a line is possible, and when mouse is on a point, the tooltip pops out with information. See Fig.5 for example.

5 Related Work

There are two related visualizations about this data that we were inspired by and made improvements upon.

The first one is from the database itself [2], which uses a time shaft to show and compare on map the satellite number and ability to launch of countries in year 1966 and year 2016. The team improves by applying time slider to show detailed number on each year.

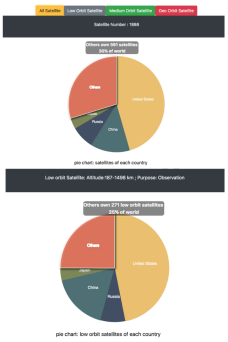

Fig. 5. Picture 1

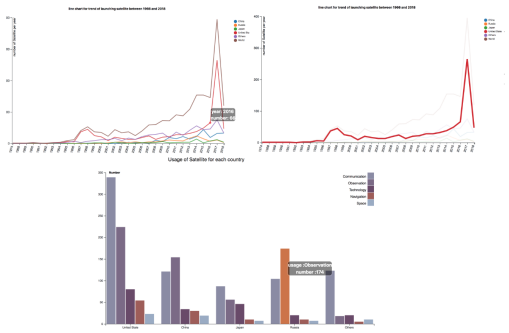

Fig. 6. Picture 2

The second one is from "every active satellite orbiting earth" [3], which projects satellites on the page based on their orbits. The team improves by making the projection compact but show enough information.

6 Conclusions

We apply many visualization principles and tricks when we design and develop the project to help reinforce human cognition through interactive visual representations of abstract data. D3 is really powerful and practical to deal with everyday data with enough customization.

The importance of visualization is perfectly revealed. Without visualization, the data will never reach to most people, let alone to analyze and discover many information about it. The process of conducting visualization is to encode information in the data into graphs and the audience can decode them by looking and interacting with the graphs.

There are still many improvements that can be used to refine the project, including design, more interaction and it's welcome to apply them if interested.

References

1. Cairo, A.: The functional art: an introduction to information graphics and visualization . New Riders,Berkeley, CA (2013)
2. UCS Satellite Database, https://www.ucsusa.org/nuclear-weapons/space-weapons/satellite-database. Last accessed 26 Nov 2018
3. every-active-satellite-orbiting-earth, https://qz.com/296941/interactive-graphic-every-active-satellite-orbiting-earth/.Last accessed 26 Nov 2018
4. Nature Earth, https://www.naturalearthdata.com/downloads/.Last accessed 26 Nov 2018
5. mapshaper, https://mapshaper.org/. Last accessed 26 Nov 2018
6. Bostock M. D3. js-data-driven documents (2016). URL: https://d3js. org. 2016 Jan.