Visualization of Reported UFO Sightings

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Fig. 1. UFOs are "proved beyond reasonable doubt": A rotating "glowing aura" traveling at high speeds that was captured from a Navy F/A-18 Super Hornet. [6]

Abstract—Reports of unidentified flying objects (*UFOs*) have sparked amateur research, government investigations, and large popular interest in the last five decades. Most reported UFOs are later identified as natural phenomena or conventional objects. However, there is a considerable body of reports about objects that are not identified, which are usually perceived as claims of observations of extraterrestrial crafts, thus raising questions about life on other planets and the likelihood of extraterrestrials visiting Earth. Although scientists in their majority have naturally greeted the topic with skepticism, it is widely recognized that answering these questions would be, among other things, of great scientific importance and a big step towards understanding the universe. We provide an interactive visualization of the reported UFO sightings in the United States in the period of 1964-2017, aiming to help any interested user explore these sightings.

Index Terms—Visualization, Map, Interactivity, Unidentified Flying Object, UFO, United States.

1 Introduction

An unidentified flying object (UFO) is a perceived object in the sky that is not readily identified. The term UFO (initially, *UFOB*) appeared in 1953 when the United States Air Force used it to describe "any airborne object which by performance, aerodynamic characteristics, or unusual features, does not conform to any presently known aircraft or missile type, or which cannot be positively identified as a familiar object" [4]. Since the 1950s, UFOs have become a major subject of interest in the popular culture and an inspiration for several movies and books [5]. The reason for this is the fact that UFOs are linked to suspected extraterrestrial aircrafts, and if this were true it would suggest that life exists beyond Earth and even more that extraterrestrials visit our planet.

Although UFOs are largely connected to this theme, it is true that for most of the reported cases the objects are identified to be ordinary or to be caused by a natural phenomenon after careful investigation. Most commonly, UFOs are identified to actually be astronomical objects, aircrafts, balloons (e.g. weather, research balloons), atmospheric or light phenomena (e.g. clouds, mirages), other atmospheric objects (e.g. birds), or, in some rare cases, hoaxes. The percentage of reports of objects that remain unidentified lies between 5% and 20% [4]. How-

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ever, this is a large enough percentage to spur a significant amount of government research and funds as well as scientific attention.

Of the most recently revealed government programs on UFOs is the U.S. Defense Department's *Advanced Aerospace Threat Identification Program* [6]. The program, which was led by military intelligence official Luis Elizondo, investigated evidence of UFOs and extraterrestrial life from 2007 to 2012, with an annual budget of 22 million dollars. In 2012 it was shuttered due to a change in the department's funding priorities, but Elizondo oversaw UFO investigations until this past October. He is convinced that this is a matter of importance and even contends that UFOs are "proved beyond reasonable doubt" (Fig.1). As for the scientific community, the recent *Breakthrough Listen Program* [7], located in the Astronomy Department of the University of California, Berkeley, is the most scientifically comprehensive search for intelligent extraterrestrial communications in the Universe to date [8]. It counts 100 million dollars in funding and it became more publicly known due to the statements of renowned physicist Stephen Hawking on alien life and his support of the program [9].

It is clear that the subject is controversial but, at the same time, most would agree that it requires research and attention. Therefore, it is important that there is a general awareness of the subject to the public. To this end, we created an interactive web-based visualization that allows the user to explore reports of sightings in the United States. It is intended to be pleasing and to give an overview of the reported sightings in the United States throughout the years, as well as the ability to drill down in order to explore characteristics of more specific areas and sightings.

The data we are using is posted on the website of the National UFO Report Center, whose head is Peter Davenport. The Center's website provides an online form as well as a hotline for reports of UFO sightings and these reports are annotated by Peter Davenport himself before they are posted in the database. Each report includes the date and time of the sighting, its duration, shape, location, and description summary (possibly including notes of Peter Davenport in double parentheses), as well as the date the report was posted.

Table 1. Data attributes

Term	Type of Variable	Example
Date	quantitative	1/12/10 21:30
City	categorical	Fairbanks
State	categorical	AK
Shape	categorical	Disk
Duration	quantitative	about 1.5 minutes
Summary		"We saw..."
Date Posted	quantitative	1/12/2012

2 Related Works

Visualizations of the UFO dataset: The dataset we are using has been popular on Kaggle which led two data visualization experts, Pooja Gandhi and Adam Crahen, to use it in their DuoDare project on their DataDuo blog [3]. The DuoDare was a project where each month one of the two experts would choose a dataset and call the other on a battle for the best visualization. The two visualizations that the experts came up with for this dataset included, among others, interactive maps, area charts, bar charts, and calendar heat-maps. Both visualizations as well as our own include a map of the United States. In Pooja Ghandi's visualization a point on the map corresponds to an area and hovering over the point shows a moving tooltip of the number of sightings that have been reported in that area. In Adam Crahen's visualization each point corresponds to a single sighting and hovering over the point shows the details of the sighting. Adam Crahen's visualization includes a calendar heat-map, which also allows the user to click on a particular year/month/weekday/hour and filter the sightings she sees. Pooja Ghandi's visualization includes an area chart of the number of sightings through the years and allows the user to filter the data over time by hovering over a particular vertical line on the area chart. This action also updates a donut chart showing the number of sightings in that year as a percentage over the total number of sightings. In addition to these, it includes two horizontal bar charts showing the five locations/shapes with the highest number of sightings, as well as two visualizations regarding the top five countries besides the United States with the highest number of sightings.

In our visualization we use the same encoding as Adam Crahen for the overview task, i.e. we use a map where each point corresponds to a sighting. However, instead of showing a static map of all the points, we populate the map over time. The user can pause this procedure by clicking on the time-slider. This allows her to explore more patterns about the way the sightings occur over the years, on top of giving an overall picture of the sightings, whereas the other two visualizations only use filtering to allow the user to explore these patterns. As an extra overview feature, we color each state based on the number of sightings that have occurred in that state. In addition, our visualization is different from the other two since it also supports drilling down in the data. It allows the user to choose a particular state to see the sightings of that state in more detail and it shows a line chart of the number of sightings of the state over time (instead of the area chart Pooja Gandhi used for a similar task). Finally, it allows the user to brush over an area in the state, thus selecting a group of sightings, and it updates the line chart of the sightings over time based on these sightings only. We believe that this additional exploration based on the state and area is more intriguing and would make the visualization more interesting and enjoyable to the user. We base this on the fact that our visualization supports the task of "What sightings have happened in my area?" which is a common question when thinking about this subject.

Visualizing geographic spatial data: Since we have geographic spatial data, we chose a map to represent them. There are several types of maps, based on the type of surface the Earth is projected on. There are three main types of projections: cylindrical, conical, and azimuthal [10]. Although cylindrical projections incur a significant amount of distortion ([11]), the Mercator map, which corresponds to a cylindrical projection, is the most popular type of map. Since it is more important that the user is familiar with what they are seeing than deriving exact conclusions on the data, we chose to use the Mercator map.

3 Process

In this section we focus on the necessary steps that we took successfully create our project. Most of the steps were prescribed for us beforehand as requirements for the final project for our data visualization course.

Initial data selection: With requirements for a class project already available to us, this dataset became appealing to us for its cleanliness and public availability. The key requirements were that we make an interactive, web-based visualization with at least two different visual encodings and two features from brushing and linking, overview, and details-on-demand. The existing visualizations of this data we found [3] left the option to incorporate brushing and linking of time with the spacial data as well as a few other features as a novel direction to head in. We found the whole subject to be amusing and felt a broad audience would be able to have fun exploring an interactive visualization of these data.

Interview with field expert: Having decided to use the the National UFO Report Center's dataset for our project, we conducted a phone interview with its head, Peter Davenport to help us understand his website and dataset better. The current iteration of the website was set up in 1995 and hosts approximately 145,000 alleged sightings, with a noticeable uptick since the option to report a sighting via the internet became available. Currently there is a weekly UFO update on Coast to Coast AM radio and the website boasts many details with images of suspected sightings, however no visualizations of the dataset as a whole. After this interview we were able to decide which tasks were most important for us to satisfy in our visualization (see 3.1).

Prototyping workflows based on feedback: Based on the tasks

outlined in 3.1, we each created different sketches that we discussed extensively with each other as well as with the teaching staff before incorporating the best features of those sketches into a final workflow to keep as a goal. Further along the way, there was an interactive feature testing session where we tested a basic D3 prototype of our visualization with our classmates. The feedback we gathered served to help us tailor the design to users less familiar than ourselves with the tool and the data behind it.

3.1 Task Analysis

The domain tasks our visualization supports are in Table 2.

Table 2. Domain Tasks

Task	Abstraction
Observe how the UFO sightings occur throughout the years	Present
Observe all UFO sightings of a particular year and specific details (such as shape)	Discover
Curiosity stimulation	Enjoy
Look for areas with high number of sightings	Search/Explore
Are there clusters of UFO sightings according to geographic area?	Cluster
Learn details of sighting	Retrieve Value
When did the sightings of a particular area (e.g. my hometown) occur?	Filter
What state has the most sightings?	Find Extremum
What date has the most sightings?	Find Extremum

In general these tasks can be categorized into two abstract tasks.

- **(T1)** Overview task:
- **(T2)** Drill-Down task:

4 Design

For the abstract tasks, we chose the following visualization idioms (Table 3).

Table 3. Visualizing the Abstract Tasks

Abstract Task	Visualization Idiom
Overview	Map
Drill-Down	Map and Line Chart

Visual Encoding and Interaction Choices:

- Points on map for representation of geographic data
- Sequential color scale for frequency of sightings on choropleth map
- Retrieve details of sighting on tooltip on hover
- Clicking on state to change the drilled-down view (hovering only affects tooltip)
- Line chart for frequency of sightings of state over time (position as a channel for quantitative value)
- Brush to choose sightings of an area for which the user wants to know information about when they occurred

Implementation:

5 Discussion

5.1 Reflections?

5.2 Future Work

This paper focused on the UFO data we worked with, the tasks we sought to implement, and the visualization design that resulted from these requirements as well as through acquired feedback. There are many features we would like to be able to include in the future, however. Among the most interesting would be to associate historical weather data with the dates of the alleged UFO sightings. Additionally, plotting sources of red flags such as airports or weather balloons would be of use in explaining a large number of sightings. The biggest challenge at the moment is acquiring a suitable dataset containing this information in a reasonable format.

6 Conclusion

We created a web-based interactive visualization providing a novel view of data originally gathered by the National UFO Report Center of thousands of alleged UFO sightings around the country. We incorporated interactivity tools such as brushing and linking to make it easier to dynamically view reported sightings on a United States map and select only reports within years ranges of interest. This allows a map to be less cluttered than existing maps and thus also allows for details-on-demand to be easier to use as there is less ambiguity of where a user is pointing. We use an appealing color palate for the task at hand and create an environment that is amusing and engaging to users interested in understanding the scale of belief in conspiracies or UFOs.

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