Geographical visualization of multivariate data using animations

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Abstract— This report covers the process of creating a visualization of geospatial multivariate data using animations. The difficulties and the advantages of visualizing data with moving objects are discussed. It is concluded that animations can show multivariate data by either alternating between two visualizations or by being used as an attribute.

Index Terms—Multivariate data, Geographical Visualization, Animation.

1 Introduction

To visualize information is to represent data in a visual and user friendly way. The process of information visualization is significantly important when making data digestible and turning raw information into actionable insights [1].

A common problem with information visualization is to visualize multivariate data. The concept of multivariate data is when the data involves three or more variables. When using multivariate data different relationships between variables can be found and therefore analyzed [3]. This reports main focus is to solve the difficulty of visualizing multivariate data, by using animations and patterns. The sole question is, can animations or patterns be used in an intuitive way to visualize multiple variables in a way that is user friendly?

To try to answer this question, different types of animations and patterns has been implemented and combined with simple color scale visualizations. Which type of animation is the most intuitive and can it visualize a variable so that any user can understand its value? The data set used has both spatial and temporal data, but the focus was on visualizing the spatial values and not the change over time.

2 Background and Related Work

Animations has been an option for geographic visualizations before. Primarily it has been used to show spatial processes where animations help show the change over time for attribute data [4].

In today's concepts of geovisualization, dynamic and interactive displays play an important role. Animations and its visual variables can be a powerful tool for map designers. It is however necessary as a designer to ask yourself "why do I need to animate these data?" [5].

It will attract the user's interest seeing thing change on a map, but will it show what the designer wants the user to see? Even tough moving objects attract more attention, they also have to attract the right attention. Otherwise animations can be seen as unnecessary.

The approach that is presented in this report is not unique or new but rather an experiment. An experiment to see how well animations can help show multivariate data in an intuitive way. This approach will not necessarily result in a solution but will provide more insight on the role of map animation for geographic visualization.

3 Data

The data set used is The Human Freedom Index's data set. It is a comprehensive global measurement of human freedom collected from 162 countries around the world. The data set contains 79 different categories as indicators of personal, civil and economic freedom. Each category has an index that ranges between the values 0 to 10, where the lower the value the lesser freedom and vice versa. The earliest year from which there is sufficient data is 2008, and the latest measurement available is from 2016. There exists measurements from 2017 and 2018 but these are not available in a data set [2].

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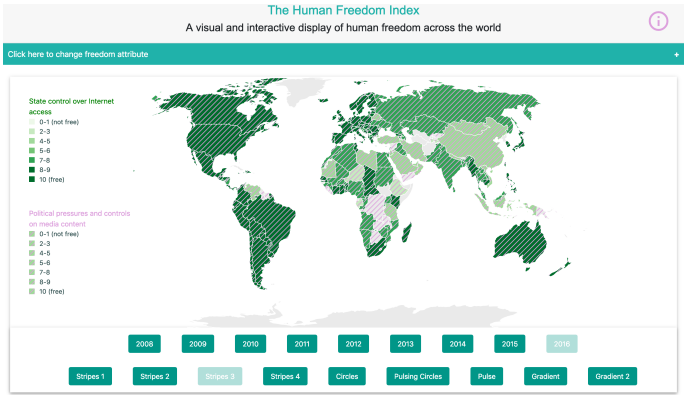

Fig. 1. The default start page. The active animation is "Stripes 3", described in 6

4 Method

To create this project a series of steps were made to create the final result. The first step was to design the design for the textures for the animations, these textures are described in section 6. To be able to use the animations data for rendering the world map was loaded from a csv-file. This data was then connected to the data from The Human Freedom Index, also in the form of a csv-file. The data included ISO country codes that could be connected with the data for the map.

The next step was to fill every country with a texture. A function was created that takes in account the two values to be displayed on each country, these are considered the primary freedom value and the secondary freedom value. A reference to the created texture is returned by the function.

A separate function for texture generation was necessary. This function generates a range of colors that represent the primary freedom value by using a color scale function. The higher the primary freedom value is the darker the color, in this case green, will be. Since the focus was not on the less freer countries, the lower values have a lighter color that does not stand out as much as the darker color.

For the secondary freedom values representation a pattern is created. Separate functions were created for all the patterns presented in section 6. These patterns were then animated by using transforming attributes that specified the patterns movement. By using these attributes it was easier to create several different animations that could even use the same pattern.

To render the world map with textures, the named functions would be called for every country and they would be filled with a texture. To clarify the colors and animations associations to the freedom values 0-10, two separate legends were created. They were also rendered with a texture the same way as the world map.

To make the web application interactive certain graphical user interfaces were implemented. These were buttons for the different ani-

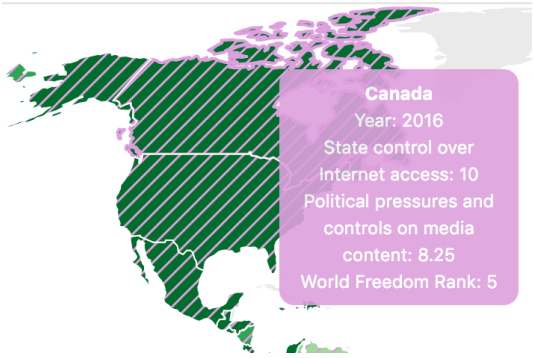

Fig. 2. Tooltip with information that appears when hovering over a country.

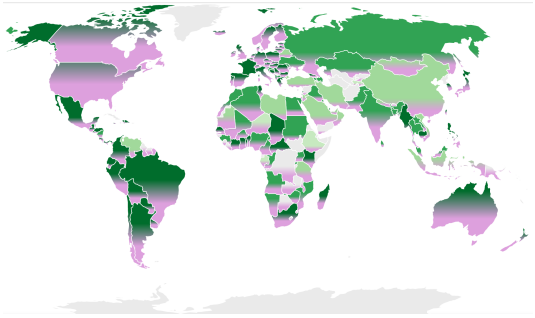

Fig. 3. This animation shows a pink color starting from the top of every country. The lower down the pink color moves, the lower the value is.

mations, buttons for the different years the data was from and a collapsible header including buttons for the choice of the primary and secondary freedom values. Every button was set with event listeners that generates new textures by re-rendering the map.

Another user friendly function was a tooltip. The tooltip appears over a country while hovering over it. It shows necessary details on demand, which is the countrys name, the values of the chosen primary and secondary freedom values and lastly the countrys global freedom rank.

5 Implementation

The implementation was in the form of a web application, using JavaScript 6, HTML and CSS. The javascript library d3.js was used to manipulate the visualizations based on the data, this was done with the help of SVG. The world map was set to an SVG element and by using d3's .attr() the countries could be filled with textures by the SVG path fill attribute. To fill the countries with animated textures, JavaScript and the SVG elements animate and animateTransfrom were used. Both animate and animateTransform contain different parameters that can be specified, such as duration and type of animation. These elements easily create desired animations and were therefore the preferred option.

6 Results

The end product can be seen in figure 1, it is an interactive web application displaying a animated geovisualization. The teal header under the web application's title is a collapsible header that includes two lists of attributes. One attribute can be chosen from each list which will be displayed on the map in a color gradient and an animation. The two legends on the left side of the map shows a range of colors and animations that represent the freedom value interval 0-10. Depending on what value a country has, the color or animation corresponding to that value will be displayed on that country.

If the user hovers over a country it will be presented with more information in the form of a tooltip. The tooltip contains the necessary information about the country and the data presented on the map. This includes the country's name, the year the data is from, the value of the first attribute, the value of the second attribute and the country's world freedom rank. The user can regulate between the years 2008-2016 using the buttons below the map.

The results includes nine different animations with related buttons. The buttons were merely there for the designer to present the animations that have been implemented during the project. Out of all the animations, three were preferred and another three were extremely hard to understand. The remaining three animations were variations of the other six.

The three preferred animations were "Stripes 3", "Circles" and "Gradient 2". Stripes 3 is an animation where several lines move across a country, the faster the lines move the higher the freedom value is. Circles is a transition from one set of colors to another, the two sets of colors represent two different attributes and their values. Gradient 2 is an animation that "drains" the country of a constant color the lower the value is, see figure 3.

The three animations with the worse result were "Gradient", "Pulse" and "Circles 2". Gradient works similar to "Gradient 2" but fills the country with a color from a scale of blue colors, the darker the color the higher the freedom value is. Pulse is an animation that flashes between two colors, one color representing the first attribute and the other color representing the second attribute. Circles 2 is a combination of "Pulse" and "Circles".

The interactive implementations are very quick with every function taking not even a second but milliseconds. Loading the application takes 3.0 ms, scripting takes 860.0 ms, rendering takes 2230.0 ms and painting takes 12600.0 ms. The final product does contain certain limitations, these are discussed in section 7.

7 Conclusions and Future Work

Based on the results, it can be concluded that some of the animations implemented did not present the data using the animation. For example, the animation "Gradient" showed the countries values by color. Even tough the second color covered the first color, it was not the animation that implied what value the country had, it was the shade of the second color. This problem was noticeable in several of the animations implemented. It proved very hard to have an animation that represented a value. Even tough that was a problem and somewhat confusing, does not mean it affected the visualization of multivariate data. For example, the animation "Circles" transitioned from one visualization to another and therefore showed both of them in an intuitive way. The conclusion here is that animations can be used in two ways, to alternate between two visualizations or to use as an attribute.

The greatest challenge with geographical visualizations was the countries different sizes. This limitation had several consequences such as bigger countries drawing more attention and a difficulty of showing intricate patterns on smaller countries. These issues could be solved with a zoom function or a different display of the world map. Ideally would be to focus on a few countries at a time instead of the whole world map at once.

It can be concluded by the results that it is easier to see differences between colors than between moving objects.

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