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Interactive Data Visualization of Christian Demographics

Dartmouth Computer Science Technical Report TR2016-812

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June 2016

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June 2016
CS/Digital Arts Thesis
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Interactive Data Visualization of Christian Demographics

INTRODUCTION —

1. Global Movement of Christianity

Christianity for the longest time has been perceived as the “Westerner’s religion” or a religion prevalent in Western countries only. The word ‘Christian’ is often associated with the United States, Europe, and other Western-affiliated nations. While this may be true for most of history up until the early 1900s, today, if we were to look at the current religious makeup of the world, we would find a much different story. While the Christian population in these western nations is decreasing, many other nations are seeing a surge in Christian belief. Our world is changing rapidly, where Islam is the fastest growing in many European nations and Christianity is the fastest growing religion in countries like Mozambique, Nepal, and many other third world countries. Today, over 60 percent of Christians come from non-western nations (Granberg-Michaelson), and this number is only expected to grow. Furthermore, the global experience of Christianity has changed drastically in the 20th century, going way beyond our modern definition of the Christian experience. Justin D. Long, a missionary researcher with ActBeyond, emphasized “the startling fact that more people have died for their faith in the Twentieth Century than in all of the previous centuries combined. During this century, we have documented cases in excess of 26 million martyrs. From AD 33 to 1900, we have documented 14 million martyrs” (Wooding).

While Christianity may be on the decline in the United States, this is not case in countless other nations. From the Washington Post, “Religious convictions are growing and shifting geographically in several dramatic ways” (Granberg-Michaelson). Christianity today has evolved into a global phenomenon that many of us are unaware of. A century ago, 80 percent of Christians lived in North America and Europe, compared with only 40 percent today (Granberg-Michaelson). The story unfolding today showcases a once Western Christianity and its move from Europe to the global South.

2. Data Visualization

Through the usage of current web data visualization tools and acquired data sets, I hope to convey to users this shift of Christianity from the North to the South. Web-development and Javascript frameworks like D3.js and Leaflet.js have made not only data visualization, but also map visualization accessible to the layman coder. These libraries have pioneered incredible ways for users to interact with the data set before them in a interactive, user-friendly, and powerful manner.

Data visualization becomes a powerful tool when dealing with inordinate amounts of information. For the user, looking through a database trying to uncover Christianity’s

global trends can be frustrating, tedious, and ultimately un insightful. Raw data only becomes useful when we apply methods to derive insight from it. However, while rows of data may be unhelpful for many, maps and creative visual representations have become the fastest and most effective way to communicate with others when done well. Visualizations allow us to see the world in a different way and allows users to uncover patterns and trends they would have otherwise just glanced over. Data visualization therefore becomes an effective tool for storytelling and mapping information into something more easily interpreted.

3. Thesis

My thesis will attempt to use the affordances of interactive data visualization to showcase the global movement of Christianity from North to South since 1900 and projected and interpolated up until 2050. Through the usage of demographic data, honest and accurate visualization, and compelling graphics, I hope to create a tool that users can use to explore this monumental movement of Christianity in just the last century.

4. Definition of Success

In this project, success will be defined by several criteria.

1: Ability to showcase the North to South movement of Christianity.

The visualization should tell the story of Christianity moving from the Western nations to Non-Western nations as seen by the move of the religion from North to South. The visualization should not exaggerate the data, but accurately portray this trend. Because of the huge difference in religious makeup today compared with the 1900s though, this should not be an issue.

2: Ability to project data from 1900 up until 2050.

The visualization should pool from data back from 1900 up until today. Actual datasets as opposed to projected datasets must be acquired for at least several years scattered throughout the 20th century to showcase accurately the changing religious landscape. Data may be projected into 2050 to display trends that may be worthy of noting and the continuation of global Christian movement.

3: Ability to use map data visualization effectively.

The visualization should utilize map visualization tools so that the user can adequately comprehend the visualization. The map visualization allows the user to see the movement on a wholistic level as well as in an effective manner. Effectiveness will be determined by comprehension surveys containing questions that evaluate user's understanding.

4: Ability to acquire accurate data sets and convey information honestly.

It is extremely important that data sets are acquired from reputable sources and that data is interpolated in a unbiased and honest manner. The visualization should represent the data fairly and should let the data speak for itself instead of the coder/designer speaking for the data.

5: Ability to create an aesthetically-pleasing, user-friendly and interactive tool. The data visualization should meet standard criteria for user-friendliness and aesthetics. The tool should be easy to use and make sense design-wise. There should be an interactive component to the design as well. Effectiveness will be determined by the average perception of usability and aesthetics on a 1-10 scale in survey format.

Through this thesis, I hope to showcase the North to South movement of Christianity from 1900-2050 in an unbiased manner through the usage of map data visualization and come out with an aesthetically-pleasing, user-friendly, and interactive tool.

OTHER WORK —

1. Christian Demographics

The religious landscape of our world today is dramatically different from that of the 1900s. Looking at the statistics from even just 50 years ago, the demographical changes were quite apparent, and although discerning the exact trends from the data may be a little less obvious, it was easy to see that there had definitely been a significant change between the religious landscape of today and that 50 years ago. Current work and many media outlets have presented statistical data that demonstrated the changing nature of religion, especially in the context of America. These demographical changes are becoming increasingly relevant to the public as more coverage is given to these issues and the religious demographic of the people we surround ourselves with continues to diversify.

The religious demographics of many Western nations have become more diversified due to denser movements of people and more flexible immigration policies. From the Pew Research Foundation, in America, there has been a noticeable increase in religious diversification marked by a decline in Christians and an increase in unaffiliation and other faiths over the last nine years (America's Changing Religious Landscape). Americans who would define themselves as religiously unaffiliated, described as atheist, agnostic, or "nothing in particular", increased by more than 6 percentage points, while growth from non-Christian beliefs is most greatly seen in the Muslim and Hindu populations. American Christianity, on the other hand though, decreased by about 8 percentage points during this same period. Another compelling example is the United Kingdom, one of the last nations to be considered a Christian nation. It has seen an increasing growth of non-Christian religions. "While the Church of England is only 'one generation away from extinction,' as Lord Carey, the former Archbishop of Canterbury, warned earlier this year, Islam is quickly coming forward to take its place. During the past two years the Church of England lost two million followers, whereas the number of Muslims in Britain grew by a million, according to NatCen's British Social Attitudes Survey" (Williams). And according to a Time Magazine article, Islam is the fastest growing religion in the world, with nearly equal shares to form the makeup of the global

population by 2050 (Rayman). The religious makeup of many of these traditionally “Christian” nations have become increasingly made up of other religions, with Muslims projected to make up a total of 10% of the European and 2.1% of the American population, outnumbering the Jewish population in America (Rayman). Granberg-Michaelson writes about how these changes, in relation to the United States at least, can be attributed to the more lax immigration policies adopted in the 1960s, allowing for other professing believers to come and influence the religious landscape.

Interestingly enough though, these demographical changes don’t necessarily mean just an increase in believers of other faiths. If we look at Christianity in the context of the world, there has been a noticeable change in the demographic of people converting to Christianity. In the case of the United States, while overall, Christianity decreased by 7 percentage points over the course of 9 years, in all minority groups, Christian faith increased (America’s Changing Religious Landscape). Asians, blacks, latinos, immigrants - they all saw an increase of believers in Christianity.

This diversification of the Christian faith can also be seen worldwide. Many people would be surprised to find out that Africa actually has some of the highest rates of Christianity in the world. As of 2000, countries like Congo-Zaire, Seychelles, and Angola all have rates of Christianity in the 90 percentile. This is crazy considering that the percentage of Christians in United States hovers around the 70 mark (The Explosion of Christianity in Africa). In nations like Korea and China, Christianity has been growing at an incredibly high rate. Although South Korea has now stagnated at 30-40 percent of the population, demographers have predicted that Christians will constitute 16.1 percent of the 1.4 billion Chinese population by 2030 (Yang). And by 2040, up to 32 percent of the Chinese population. These examples showcase just how much our understanding of Christianity has changed and will continue to change in the upcoming years.

A religion often associated with Western nations, Christianity has increasingly diversified globally. In Western nations, Christianity’s adherents are much more likely to be minorities than in the past. While on a global scale, Christianity is being adopted more so by non-Western nations. As Washington Post writer Wes Granberg-Michaelson covered the shift in Christianity in the United States and in the world (Granberg-Michaelson). Over 60 percent of Christians come from Non-Western nations today. And this number is only going to increase.

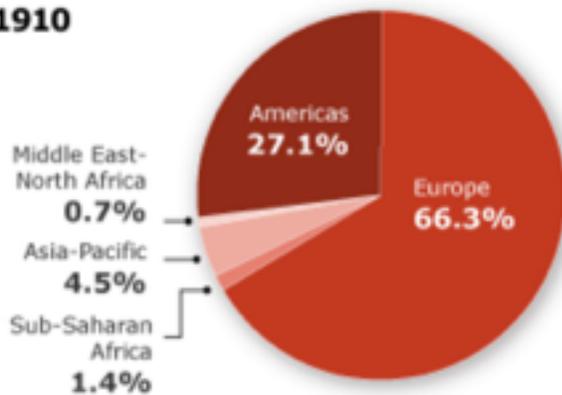
This monumental North to South shift in Christianity is what I hope to show through the usage of data visualization.

2. Demographic Visualization

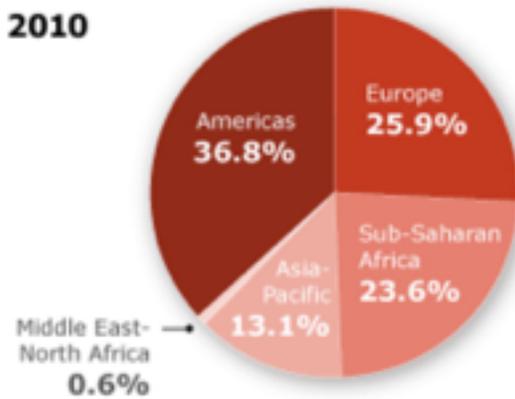
To showcase such demographical data, currently, the state of art for Christian demographic data ranges from bar charts/ pie charts to static map visualizations. From a study conducted by the Pew Research Forum, data visualization on average usually consists of bar charts, tables, and pie graphs. For example, to showcase the changing demographic of Christians, pie charts, as shown in **Figure 1**, display the different

Regional Distribution of Christians

1910



2010



Figures for 1910 are from a Pew Forum analysis of data from the Center for the Study of Global Christianity. Percentages may not add to 100 due to rounding.

Pew Research Center's Forum on Religion & Public Life • *Global Christianity*, December 2011

Figure 1: Standard representation of Christian demographic data to showcase the change of regional distribution and diversification of Christianity. (Liu)

makeups of Christianity in 1910 in comparison to 2010. This is an effective way to showcase the changing regional distribution of Christianity, but loses a lot of the geographical context in the process. On the other hand, visualizations like **Figure 2a** and **Figure 2b** provide geographical context for the data but fail to show how Christianity has changed in a such a static representation.

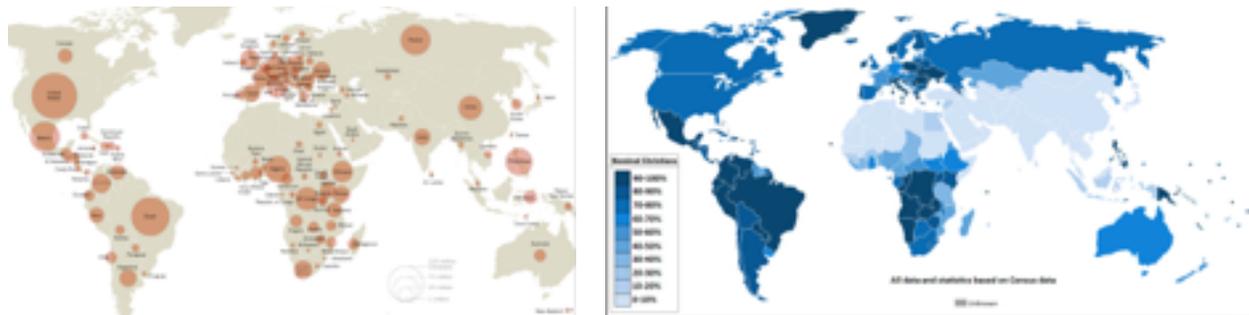


Figure 2: Static geographical representations of Christian demographic data. Figure 2a (on the left) uses the size of circles to represent Christian population sizes (Liu). Figure 2b (on the right) uses a choropleth representation of the data, showcasing percent Christian by the intensity of the blue. The darker the blue, the higher the rates of Christianity (Christians in the World).

3. Need for Christian Demographic Visualization

The problem with such static data visualization examples is that they either A) miss the geographical context and/or B) miss the temporal context. Pie charts may be a bit too simplistic to showcase the movement of Christianity across the world. And to use pie charts with countries as opposed to continents may be confusing. Additionally, map data visualizations are a good representation of what Christianity looks like currently, but they fail to show how Christian demographics have changed over the past century and how it will continue to change into the next upcoming year.

There therefore is a need for Christian demographic visualization that can not only tell the story of Christianity's movement, but is also able to do so within its geographical context while also employing the element of time. This can be done so through data animation and interactivity.

4. Interactive Data Visualization

Current state of art for interactive data visualization can be exemplified by two examples that showcase map-based data visualization in a both effective and easy to understand manner.

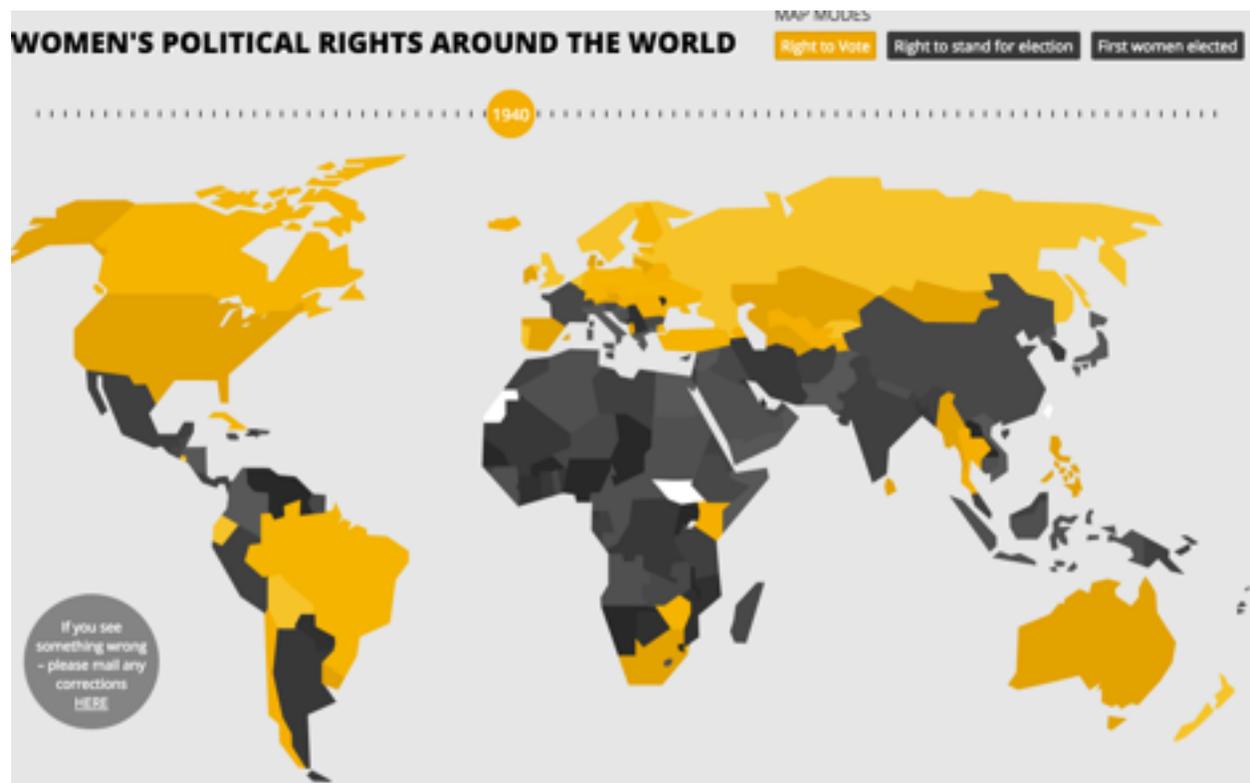


Figure 3: This data visualization showcases Women's political rights around the world. When a nation establishes voting rights for women, the country turns yellow (Rogers).

The standard for good map data visualization is shown in **Fig. 3**. Well-done temporal map data visualization demonstrates a trend, pattern, or story through the employment of data animation that changes with time. In this case, the slider at the top represents time. The user can drag the scale to the year they desire to see the number of countries that have given voting rights to women in that particular year. The shades of yellow are

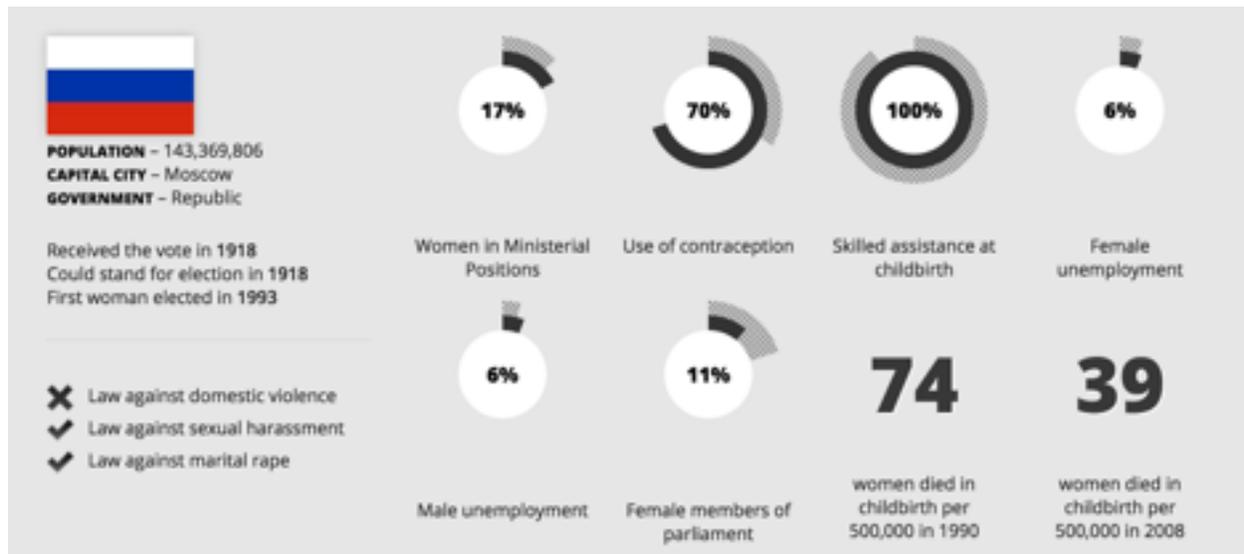


Figure 4: Expandable screen containing more information related to women's rights in a particular country (Rogers).

not meant to denote any sort of data and is only used to delineate boundaries between countries. Scrolling over a country, you can see the year the country gave women the right to vote. Clicking on a country, you can see more data related to the women's rights in the particular country as you can see by **Fig. 4**.

Fig. 5 showcases another good example of temporal map data visualization in application to the movement of refugees around the world. The coding project called "The Refugee Project" tries to show the movement of refugees throughout the world. Instead of binding the data to color in a choropleth manner, the visualization chooses to bind data to the size of the circle. The larger the circle, the more refugees there are. This makes for a very dynamic visualization, especially with data that changes a lot over time from year to year. Some additional data relating to overall statistics are located on the left side.

Some unique additions include several features pertaining to the timeline aspect of the visualization. The coder's decision to include the use of automatic animation makes it very easy for users to automatically see the movement of refugees over time upon arriving to the website. The user still has control to move throughout time to see various data points, but automatically animating the data makes it easier for users to understand the "over time" nature of the visualization.



Figure 5: This data visualization showcases the movement of refugees over time. The size of the circle represents how many refugees are coming from that nation (Ijeoma).

While the Women’s Political Rights visualization easily showcases the increase of rights for women around the world over time, the story that “The Refugee Project” is a little bit more difficult to discern. The data more likely serves to show the enormous amount of refugees and their movement to places around the world as opposed to a specific trend. Stories related to the refugees in a particular nation pop up as document icons over time and major headlines appear on the left side, but major trends are difficult to discern overall from this well-executed visualization. That may be a choice on the designer to create a tool to explore refugee movement as opposed to show a specific trend.

Data visualization makes it easier for users to interpret and understand data. In scenarios where multiple static views limit the data, the usage of interactivity and temporal changes can enhance and better represent the data. Through the example of these temporal data visualizations, I hope to create a visualization that employs similar techniques in temporality (having a timeline, automatic animation), data-binding (enlarging circles), and interactive data (clicking on a country) to create a dynamic visualization that tells a specific story of the movement of Christians from North to South.

WHAT I DID —

1. Datasets

Datasets were acquired from the World Christian Database from the Center For the Study of Global Christianity at Gordon-Conwell Theological Seminary. The database “provides comprehensive statistical information on world religions, Christian denominations, and people groups. Extensive data are available on 9,000 Christian denominations, 13,000 ethnolinguistic peoples, as well as data on 5,000 cities, 3,000 provinces and 234 countries” (World Christian Database). This data set is an authority on Christian demographic data. Since demographic data is difficult to find in the 20th century before the 1980s, I decided to use this data set that samples from 1900, 1910, 1950, 1970, 2000, 2010, 2015, 2020, 2025, 2030, and 2050. The uneven data acquisition dates allows for an interesting challenge in data visualization, but finding other data sets and combining them with this data set may create discrepancies in the data due to the different metrics that people use to evaluate Christian demographics. To accommodate for the uneven data set, I interpolated annual growth rate points so that there would be data for every decade. Annual growth rate was used since I thought that would make more sense for users than anything else.

2. Data Visualization Framework

For this visualization, I chose to use D3, which is a Javascript library for creating data visualizations. D3 stands for data-driven documents, which means that the data provided by the coder is connected to HTML documents through D3. D3 is able to load data into the browser’s memory, bind data to elements within the document, transforming these elements by interpreting the data into a visual element, and transitioning elements into different states based on user input. This transformation and transitioning aspect is what makes D3 suitable for this project. D3 employs overwhelmingly elegant transitions that make the data visualizations flow very well from one transition to the next. Additionally, D3 makes it very easy to customize visualizations exactly the way the coder wants it to be. Considering that the data set will involve a lot of transitions from year to year and that the data is pretty unique, D3 seemed like a good tool to use for this data visualization. Although learning D3 on top of web development may result in a steep learning curve, the benefits of a powerful visualization outweigh the cons of an extended learning process and any of the pros offered by cookie-cutter visualizations that wouldn’t necessarily fit the visualization requirements.

1: Map visualization

The map data was visualized by binding the data acquired to circle SVG elements. To animate them, annual growth rates were calculated (the percentage increase in Christians in one year) for each decade mark and for every country. As you can see from **Fig. 6**, each circle represents the growth rate for every country. A red circle means a negative growth rate, while a green circle indicates a positive growth rate. The size of the circle represents how large the growth is. Larger circles represent larger growth rates. The same goes for smaller circles. By binding data to the radius size, this visualization was able to dynamically change based on the growth rate.



Figure 6: Screen Shot of the data visualization including both red and green circles. Red circles indicate negative growth. Green circles indicate positive growth. As you can see, this glance at the 1960 annual growth rates shows how high Christian growth rates were in southern Africa and the southern part of the Middle East in 1960.

I decided to visualize the growth rate as opposed to the number of Christians since growth rates highlight the surprisingly fast growth of Christianity in Africa and other southern and non-western countries.

2: Time visualization

Time visualization was achieved by binding data to a slider as seen in **Fig. 7**. The time slider goes from 1900 to 2050. By binding the data to the a time slider, users can explore for themselves different years in depth. There is also the option to watch the visualization via animation to get a wholistic sense of the movement of Christianity.



Figure 7: Screen shot of the time slider. Time slider allows user to toggle through different decades to see how growth rates have changed over the years. The largest trend users should notice is the movement of Christianity to the south. This is indicated by a strong growth rate in southern hemisphere countries like the Congo, Uganda, and the Philippines.

3: Interactive visualization

The visualization is made to be interactive so that the user can gain more information.



Figure 8: Screen shot of user interactivity. When users can click/scroll over countries, the country will be highlighted and its name will appear as well. When the user clicks on a country, information about the country's Christian growth rate appears on the left side.

As shown by **Fig. 8**, Users can click on different countries to look at the growth rate up close. When you click on the country, the side dialog stays on that country even when the visualization is automatically playing itself so that users can see how the number changes as time goes by. Additionally, you can toggle through the time slider to see how the number changes manually.

6. Measure of Success

In order to measure the success of this project, a survey was conducted with 20 students to determine its efficacy. The survey is composed of 5 questions: 4 comprehension questions and 2 opinion-based questions.

The questions are as follows:

- 1) What do the circles represent?
- 2) What do the colors represent?
- 3) What was Libya's Growth Rate in 2000?
- 4) What is the biggest trend that you see over time?
- 5) Was it easy to use?
- 6) Was it interesting?

The first 2 questions deal with general understanding of the data visualization. The third question deals with understanding how to use the tool. The fourth question deals with the biggest trend students see over time after only 2 minutes of exploring. The fifth

question deals with usability. Finally, the last question deals with aesthetics and how interesting the visualization was.

What do the circles represent? (20 responses)

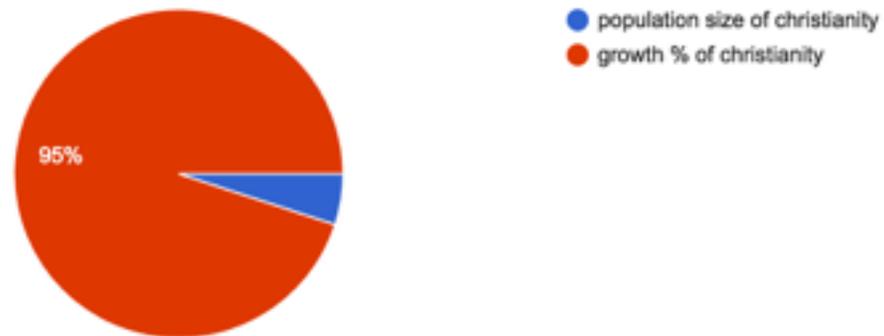


Figure 9: Question 1: 95% of People answered correctly.

What do the colors represent? (20 responses)

green is growth red is decline
green is growth red is decline
positive/negative
positive/negative
red = negative; green = positive growth
growing or shrinking? not sure
green: growth red: decrease
positive or negative growth rate
Growth is green and decline is red
Green is increase, red is decrease
Positive Growth= green / Negative Growth= red
Green - Growth, red - decay

Figure 10: Question 2: Everyone answered this question correctly.

What was Libya's Growth Rate in 2000? (20 responses)

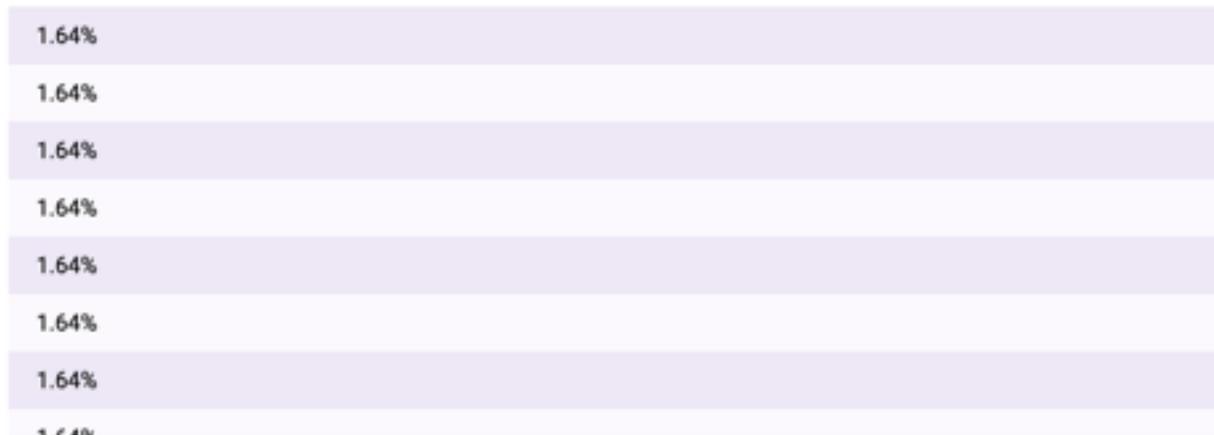


Figure 11: Question 3: 85% Answered Correctly. A couple answered this question incorrectly.

What is the biggest trend that you see over time? (19 responses)

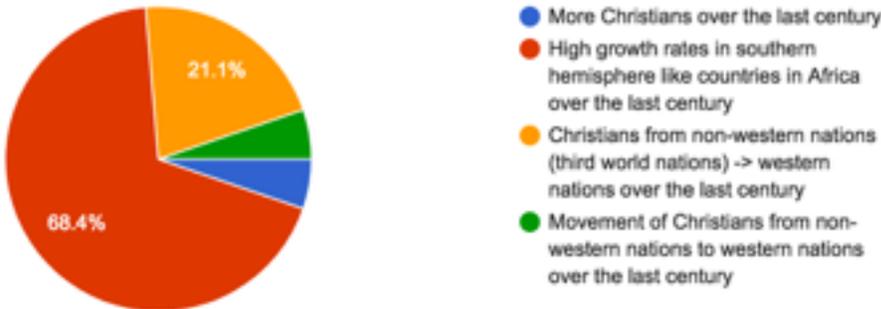


Figure 12: Question 4: 68.4% answered with the response I hope people would respond with.

From the results, the thesis was pretty successful with all comprehension questions and orion-based questions at the very least scoring around a 7/10. Almost all users understood what the visualization was showing. All them pretty much could figure out Libya's growth rate and how to interact with the tool (Fig. 11). The thing people struggled with the most is the biggest trend that they saw overtime. Maybe having the it animate automatically from the beginning would make the picture more clear. However, I have a feeling students rushed through the survey, resulting in misreading Fig. 12's answers. Lastly, there seemed to be pretty good reception overall of the website. The website for the most part is easy to use. Additionally, many people (50%) thought it was a very interesting visualization.

Was it easy to use? (20 responses)

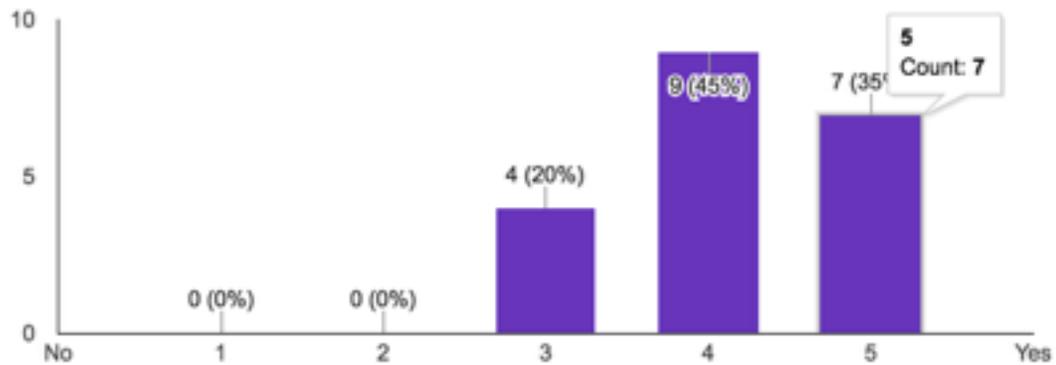


Figure 13: Question 5: Most people thought the website was easy to use (Highest category: 4/5).

Was it interesting? (20 responses)

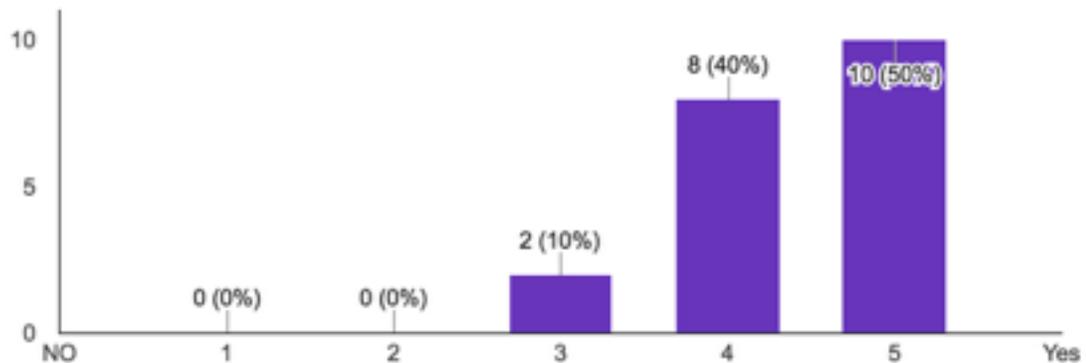


Figure 14: Question 6: Most people thought the website was interesting (Highest category 5/5).

Though this website, I hope that many people would begin to understand how global our world is becoming and how Christianity is not merely just a Westerner's religion.

WHAT TO DO NEXT —

1. Future Work

In the future, I hope to continue work on this project and develop several additional features.

1: Use of AngularJS

AngularJS is a javascript framework that allows for a more extensive and flexible use of HTML and javascript, especially in the context of dynamic web development. It's a really strong framework for use in single-page web apps and interactive data visualizations. I would hope to learn AngularJS and recode the project with their framework. The framework deals with large amounts of data well and has a very expressive vocabulary that can be added to make code documents more easy to understand. AngularJS also works really well with other javascript libraries. The problem with D3 is in its data-binding capabilities that are somewhat clunky. It is a hassle to bind data to visualizations and deal with large amounts of data at the same time. With AngularJS, data-binding automatically updates the viewer whenever the model and data changes. It makes it super convenient to parse through data documents and eliminates awkward DOM manipulation through D3. Secondly, when adding in more detailed data and panels pertaining to specific countries, it becomes a very useful tool. Instead of having to go to a different page, AngularJS makes it super easy to develop for single-page web apps that contain panels, different types of information, and etc. It becomes a very important tool for the back-end organization of front-end data manipulation and lets the D3 visualization speak for itself. In the future, I would hope to build off of AngularJS and work with D3 and Leaflet as extra libraries.

2: Country Profiles - more interactivity

I hope to expand on the interactivity component to extend the visualization's exploratory capabilities. Upon clicking a country, more information about the historical movement of Christianity in the individual country should be shown so that users can interact with the information on a by-country basis. The movement of Christianity in the country can be shown with a simple line graph over time and other demographical data could be added to give the user more contextual information about the country. This would create a tool that users would not only look at and use to understand demographical changes in a global context, but a tool that users can use to explore these changes on a local context. Additional content like the history of the nation and important events that have caused dramatic demographic changes in the country's timeline can also be shown. This would give users who asks the question "Why is this trend happening?" to delve in deeper for themselves. It also gives the user who is curious about a single country to learn more.

3: Alternative Visualization Exploration.

0. Muslim visualizations

Unfortunately, Islamic demographical data is really hard to come by that expands beyond the late 20th century. However, as technology expands, as Islam continues to expand in Western countries, and as new historical data sets continue to be found and catalogued, there may be more data available to visualize the historic movement of Islamic groups in the future. And even so, the movement of Islam in the last 10 years can be visualized in an interesting way to showcase the movement of Islam into Western nations. And how countries like the UK have become some of the most reviving Muslim nations (Beckford).

1. Listing Countries in order of conversion rate

In future visualization work to expand upon the current one, it may be helpful to rank the countries based on highest conversion rate. This will give people the opportunity to not only see the North to South movement of Christianity, but also make it a lot easier for users to attach specific countries to the movement. It would also visualize the data in not just expanding/contracting circles, but numbers as well to give users a tangible frame of reference for the data they are seeing.

2. Information based on people group

One item that might help expand the current understanding of historical global demographic movements is the employment of visualizations based on people group. A people group is a cultural group within a country defined by a unique culture or language separate. This allows for extremely unique visualizations and information display. For example, in Turkey, I was surprised by the huge drop in professing Christians that I discovered in the dataset - from 3 million to 4,000. All within tens of years. With just a small amount of research, I found out that this huge drop was the result of the Armenian Genocide in the early 1900s of Turkish history (United Human Rights Council). Most Armenians were Christian, so when more than 2 million people were murdered in this genocide, it is understandable why such a demographical change occurred in the data set. Since most Turkish people are not Christian, information like this would be extremely interesting to explore on a by-people group basis and would give a more accurate portrayal of the global movement of Christianity.

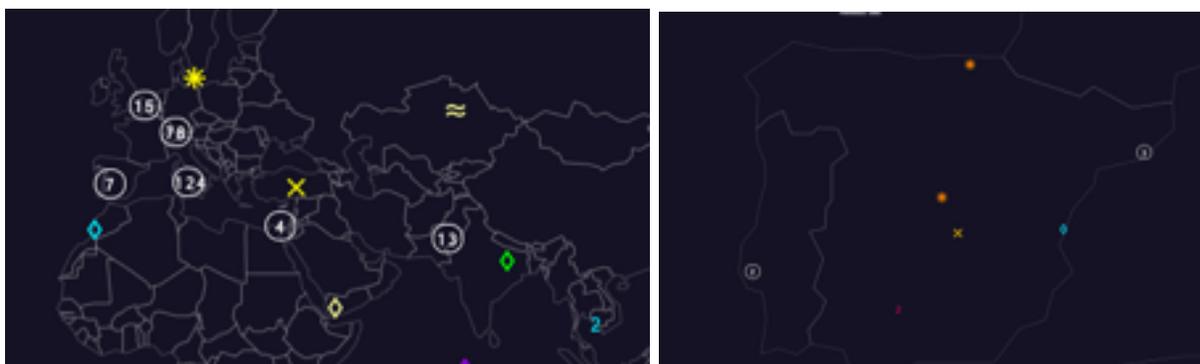


Figure 10: Alternative visualization based on people group. Since there can be as many as a hundred people groups in one country, the best way to visualize this data may be a condensed view when zoomed out (left) and an expanded view when zoomed in (right).

Thinking more into this visualization, an interesting avenue to explore would be to layer the zooming capabilities of the visualization with continually expanding views. This can be made possible through Leaflet and strategic data parsing and layering. Each white circle as seen in **Fig. 10** would represent how many people groups there are in that area. As the user zooms in, the circles break off into more regions to better showcase the number of people groups. This tackles the problem with having a lot of data on an expanded view. If the user is curious, zooming into the specific area should allow the user to see a more expanded view of the data. This visualization would only be able to show recent data since the concept of people group is a much more modern concept and data exists for the last 10 or so years. That being said, it can be a very powerful tool to explore data at through a very detailed lens. Upon clicking a country, detailed information about the country's people groups may also be accessible to the user. While upon clicking a people group, detailed information about other countries with the people group could come up.

These visualizations would all posit as interesting avenues to explore in the future.

Thesis located at applesonw.com

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