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Die Visualisierung der Evolution von kulturellen Modellen

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FAKULTÄT FÜR !NFORMATIK
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The Visualization of the Evolution of Cultural Models

BACHELOR'S THESIS

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in

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at the TU Wien

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Hannah Clara Bayat

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Wien, 13. August 2019

Hannah Clara Bayat

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Kurzfassung

Kultur ist ein faszinierendes Phänomen, das zahlreiche Aspekte unseres Lebens beeinflusst. Kulturelle Modelle streben an, diese komplexen Strukturen aus ethischen und gesellschaftlichen Werten zu beschreiben. Zwei kulturelle Modelle wurden bisher definiert: das Hofstede Modell [Hof11] und das GLOBE Projekt [GLO04]. Beide dieser Modelle definieren ähnliche Attribute zur Beschreibung von Charakteristika einer Gesellschaft, zusammengefasst in sogenannte kulturelle Dimensionen.

Um die Komplexität von kulturellen Modellen und dessen Informationen besser zu verstehen, gibt es Programme, die die komplexen Daten visualisieren. Aktuelle Programme zur Visualisierung von kulturellen Modellen nutzen unter anderem Balkendiagramme, Boxplots und Scatterplots, wobei jedoch nur ein kleiner Teil der Information abgedeckt wird. The existierenden Programme decken nicht die vollständige Information ab und missen wichtige Aspekte. Wir möchten diese Lücken schließen und einen Weg finden, um ausgewählte Daten einfach mit einander zu vergleichen. Des weiteren, möchten wir eine Visualisierung designen, die Kulturen und kulturelle Regionen identifizieren kann.

Wir versuchen ein Programm zur Visualisierung von kulturellen Modellen zu entwickeln. Das Programm zeigt die gegebenen Daten in einer einfachen Art und Weise, durch neue Ansätze und die Verbesserung alter, an. Zunächst analysieren wir die bestehenden Daten und herauskristallisieren die Kerninformationen sowie die Kernfunktion unserer Visualisierung. Anschließend liegt das Ziel in der Deginition der Vorteile und Nachteile von existierenden und aktuellen Ansätzen. Durch das Kombinieren der Stärken und die Verbesserung der Schwächen der bestehenden Programme, versuchen wir die Schwierigkeiten und Ziele, die wir mit einem neuen Ansatz erreichen möchten, zu identifizieren. Letztlich widmen wir uns aktuellen kulturellen Anwendungen, indem wir unsere Visualisierung nutzen und nach Gemeinsamkeiten, die wir nicht vermuten suchen.

Abstract

Culture is a fascinating phenomenon influencing various aspects of our lives. Cultural models seek to describe the complex structure of ethical and societal values. Two main cultural models have been defined so far: the Hofstede model [Hof11] and the GLOBE project [GLO04]. Both models define similar attributes to describe characteristics of a society, summarized in so-called cultural dimensions.

To better understand the complexity of cultural models and the information given there are tools that visualize the complex data provided. Current tools for the visualization of cultural models make use of barcharts, boxplots and scatterplots, while only covering a small part of the data and information given. The existing tools do not cover the information completely and miss vital aspects. We want to fill these gaps and seek to find a way to easily compare selected data with each other. Moreover, we want to design a visualization that can identify cultures and cultural regions.

We try to create a tool to visualize cultural models. The tool displays the given data in an easy way, by using new approaches and improving existing ones. First, we analyze the data given, to crystallize the core information and main feature of our visualization. Next, the goal is to define the advantages and disadvantages of the current and latest visualization approaches. By combining the strengths and improving the weaknesses of these existing tools we try to specify the difficulties and goals we want to achieve with the new approach. Lastly, we look at ongoing cultural applications by using the developed visualization tool and look for similarities where we do not expect them.

Contents

CHAPTER 1

Introduction

1.1 Motivation

"Culture is the collective programming of the mind that distinguishes the members of one group or category of people from others“ [Hof11, p. 3]. This is just one of many definitions of culture. With globalization and the world becoming a melting pot, cultures are changing and fusing constantly.

So-called cultural models have been used to analyze people's behaviors and to measure different aspects of a culture. They are based on various attributes which describe general characteristics of different cultures, that for instance are associated with countries. Geert Hofstede [Hof11] has defined six dimensions for cultural models. However, there is also the GLOBE project [GLO04] that sets nine different dimensions to describe a culture. There have only been a few attempts to visualize these cultural models in the past. These visualizations have so far only represented a small part of the data and are therefore missing valuable information, that is necessary to have a better and complete understanding of the given data and apply the gained knowledge to professional fields.

By finding correlations between the cultural dimensions as well as between the scores and other societal attributes and behaviors we find answers to phenomena in various aspects of a society, such as integration, marketing and economics. Moreover, there are correlations between cultural dimensions and for instance a country's wealth, its history or its population. The exploration of these correlations leads to the explanation of a society's purchase behaviour which for instance is of use for marketing purposes.

The results of visualizing cultural models can find application in societal sciences, to analyze and define cultures but can also be of interest to curious people, who seek to understand cultures of different regions of the world and their unique behavior. A visualization of the given data enables the easy examination of the available information for everybody and without any previous knowledge.

1.2 Goal of the Thesis

The goal of the thesis is to find new ways to visualize cultural models and their evolution, to make use of the visualization and to get valuable information from the data given. We want to find a creative way to visualize data from cultural models within an aesthetically pleasing application, which can change the way we perceive cultures. Finding similarities between countries has the potential to change the way we look at people and can provide a new perspective of how culture is defined. We will answer the following questions:

- How can we visualize all cultural dimensions, e.g., characteristics of the cultural models, comprehensively?
- How can we compare data from different cultures through information visualization?

Our implemented visualization allows the comparison of cultures and countries and the identification of regional similiarities and differences. By using different visualization techniques we explore the relations between a country's geographical location and its associated cultural dimensions. Displaying the given data for each country in different representations allows date exploration and a detailed analysis for hypothesis generation or confirmation. Our contribution is the visualization of cultural models and functionality for the comparison of cultures and contintents.

CHAPTER 2

Related Work

When talking about cultural models, there are two widely known approaches. There is the model created by Geert Hofstede et al. [Hof11] and the GLOBE project [GLO04]. The following chapter gives a brief overview on both approaches.

2.1 The Hofstede Model

According to Hofstede et al. a society is defined by six attributes corresponding to the six dimensions of culture. The data gained for the first four dimensions derives from the first study held on this topic in 1969. A study conducted later, in 1988 led to the finding of the fifth dimension and finally Michael Minkov's survey in 2007 added the sixth dimension. As countries were added in the second and third study a lot of the countries only have data for the last two dimensions. The addition of the fifth and sixth dimension will be referred to as steps of the evolution. The six dimensions of culture are defined as the following:

1. **Power distance (PDI)**
   Dimension 1 describes the extent to which a society accepts the occupation of high positions by others. A low power distance index translates to the feeling of inequality as something wrong and something that should be reduced. In societies with a high power distance there is only a limited number of people from whom the power comes, whereas on the low side the use of power is distributed into legistlative, executive and judiciary.

2. **Individualism or collectivism (IDV)**
   Dimension 2 is the independence with which people make decisions. In a collective culture a person knows their position in the society, meaning that their decisions and actions affect not only themselves but their larger surroundings or rather tribes

as well. Wealthy countries lean towards individualism and people in these societies tend to walk faster because their lives are happening at a faster pace.

3. **Masculinity or femininity (MAS)**
Dimension 3 does not regard to the gender of a society but rather whether its behaviour is more stereotypically man- or woman-like. Low scores in this dimension mean feminine societies. Higher scores relate to masculine societies. Femininity relates to a weak role seperation between men and women. Feminine societies try to balance family and work equally, whereas masculine societies see work as a reason to neglect the family. Masculine societies admire the strong and disdain the weak. A low score means there is often jealousy of highflyers and sympathy for the weak.

4. **Uncertainty avoidance (UAI)**
Dimension 4 is the extent to which a society feels threatened by unknown or ambiguous situations. It does not refer to people's risk avoidance. A high uncertainty avoidance score relates to a society with more stress and anxiety and the feeling of danger when facing something different or new, including different people. People with a high uncertainty avoidance also need and take more time to get acquainted to people and situations.

5. **Long term orientation or short term orientation (LTO)**
Dimension 5 describes whether a society is long term oriented or short term oriented. In long term oriented societies good and evil are relative and can change over time, while in short term oriented societies good and evil are absolute and always stay the same. Traditions can change in long term oriented societies, meaning two traditions can form into a new one while in short term orientations two traditions always contradict each other. In long term oriented societies common sense is important to solve a problem and one tends to choose a middle way or compromise rather than an extreme like in short term oriented societies.

6. **Indulgence or restraint (IVR)**
Dimension 6 describes the feelings of subjective happiness or unhappiness and the control of people's own lives. A low score in this dimension relates to restraint whereas a high score means indulgence. People in indulgent countries perceive the control over their personal life as being masters of their own lives and generally have an optimistic and positive attitude and tend to have extroverted personalities. Indulgence leads to finding having friends important and taking active participation in sports, as opposed to letting others do the sport like in restraint countries. Restraint countries and societies generally feel and act the opposite as the describes attributes.

Every dimension has its own meaning to the culture of a country's society. Most countries find themselves in the middle of the extremes of the dimensions. The values for countries can only be measured relatively to other societies. The scores for each of the explained dimensions can change very slowly over time, since they are values given from parents to children and handed over in each generation. However, the relations between the countries remain the same. Therefore the scores for the dimensions might change, but the general classification stays the same since all other countries undergo the same transformation. Summed up the scores shift with time passing, but can be expected to be stable over time. [Hof11]

2.2 The GLOBE Project

The GLOBE project conducted in 2004 dealt not only with culture but also with leadership. The data was gained with a quantitative study based on surveys. First, the project measured various attributes of societal culture and crystallized nine dimensions of societal culture. Some of these dimensions overlap with those defined by Hofstede. The nine dimensions as specified by the GLOBE project are the following:

1. **Performance orientation**
   The "Performance orientation" describes the extent to which a society encourages its members and rewards them for their achievements.

2. **Assertiveness**
   The "Assertiveness" of a culture characterizes people's agression, assertiveness and confrontation in interpersonal relations and discussions.

3. **Future orientation**
   The "Future orientation" of a culture explains the degree to which a person is planning ahead and investing in the future, similar to Hofstede's fifth dimension.

4. **Humane orientation**
   The "Humane orientation" of a culture explains the societal encouragement for fairness, generosity and kindness.

5. **Institutional collectivism**
   The "Institutional collectivism" of a culture describes the extent to which resources are distributed collectively and actions are taken with the consideration of the collective, similar to Hofstede's second dimension.

6. **In-group collectivism**
   The "In-group collectivism" of a culture includes the degree to which a society expresses pride and loyalty to a collective.

7. **Gender Egalitarianism**
   The "Gender egalitarianism" of a culture is the dimension measuring the gender inequality within a society.

8. **Power distance**
   This dimension matches the description from the first dimension of the Hofstede model.

9. **Uncertainty avoidance**
   This dimension matches the description from the fourth dimension of the Hofstede model.

Moreover, the study defines 21 dimensions of leadership divided into six global dimensions, which are not of interest for the purpose of this thesis and therefore not further discussed. [GLO04]

2.3 Existing Visualizations for Cultural Models

Current visualizations include worldmaps, barcharts, boxplots and scatterplots. In the following we will discuss their advantages and disadvantages. The visualizations on the

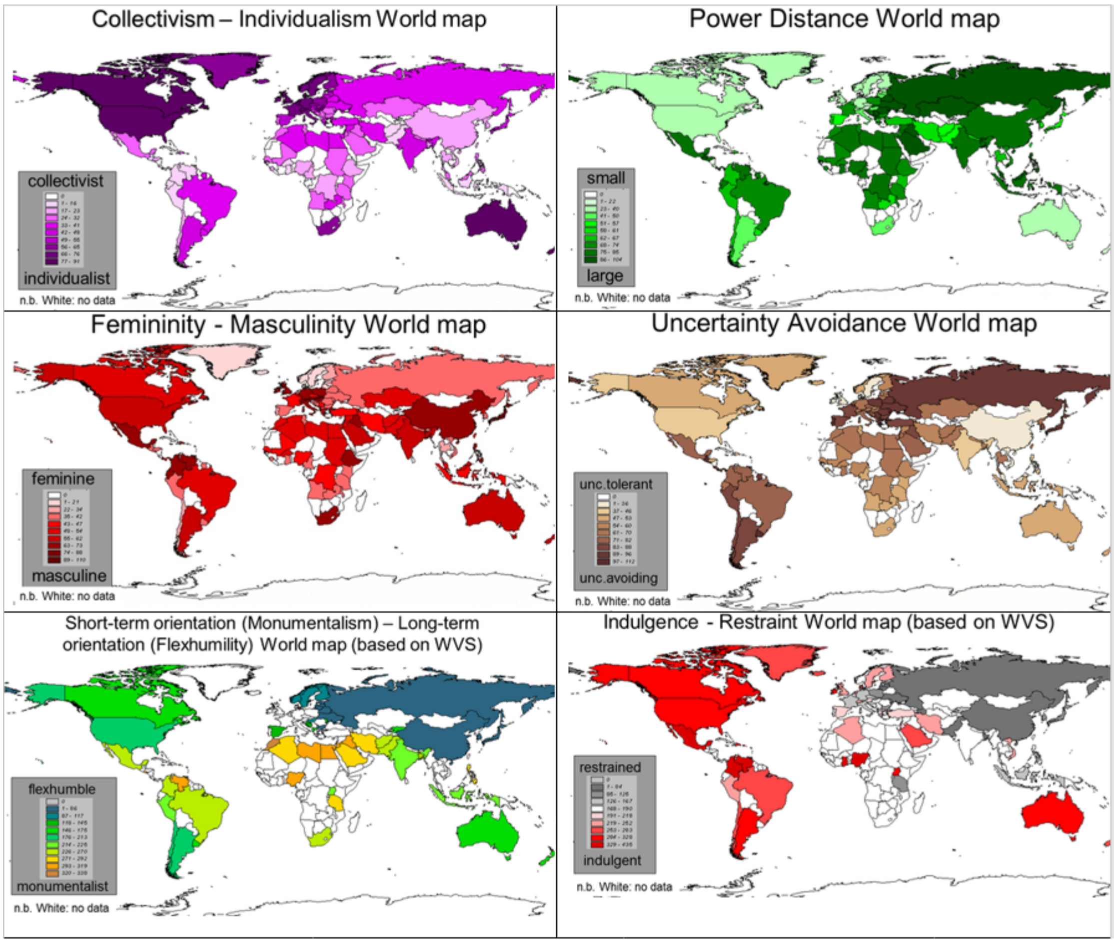

Figure 2.1: Visualization of the Hofstede Model by Michael Minkov [Hofb]

Hofstede website, orginally found in the book "Why we are different and similar" by Michael Minkov, [Min07] show each dimension in a seperate worldmap, as seen in Figure

2.1. Each map has its own colorscale which makes it easy to distinguish between the dimensions. The colorscales are discrete and categorize the values into ten fractions. Thus, one cannot quantify the exact value of a country and it is hard to compare countries further away from each other, since the map is the only element of visualization there is. Two countries with very similar but still varying values are colored in the same color, causing the difference to get lost in the visualization. Furthermore, the maps for the first four dimensions are colored with a sequential colormap. As for the fifth dimension the colorscale is an interpolation of two colors, eventually including more than two colors. The colorscale of the sixth dimension makes use of a divergent colorscale.

Another approach uses barcharts to visualize the Hofstede dimensions. As seen in Figure 2.2 up to four countries can be selected to be displayed. For each dimension a bar

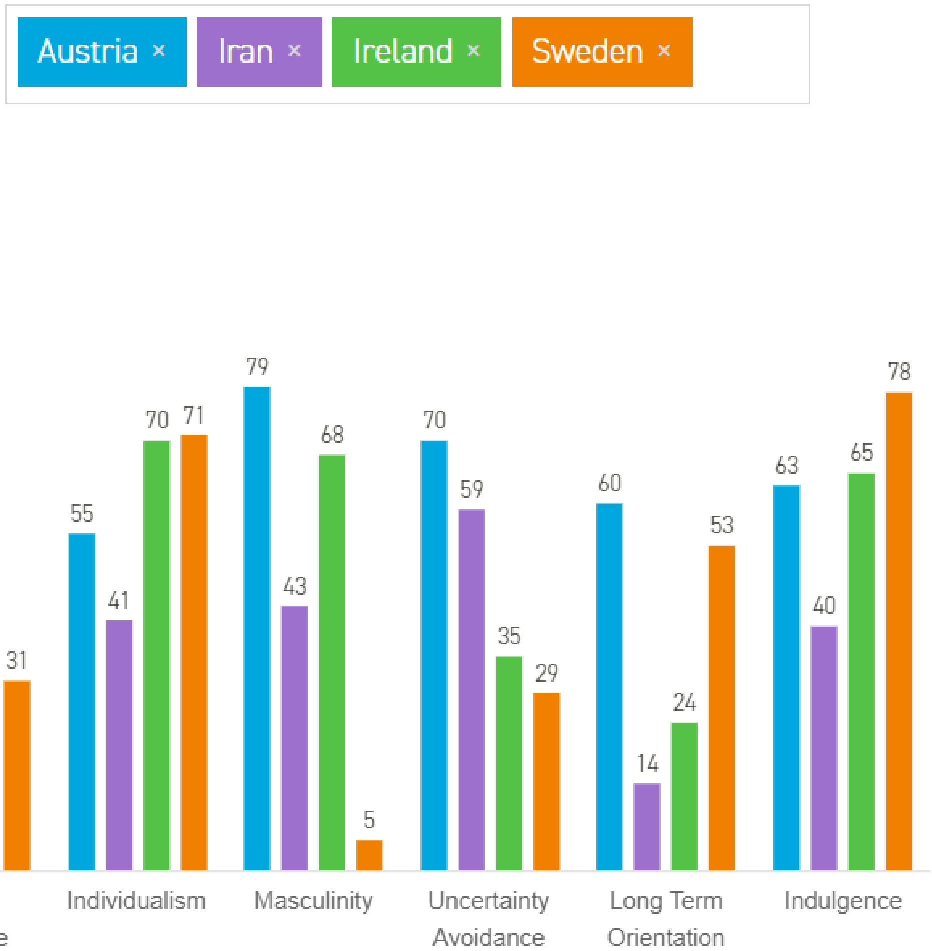

Figure 2.2: Visualization of the Hofstede Model with Barcharts [hofa]

is created above the corresponding label. The bars are labelled with the exact value for the country and dimension. The advantage of the barchart is the direct comparison of the values displayed above each bar as well as the height of each bar. Furthermore, the barcharts are very compact and do not take up much space which allows an easy overview of all the dimensions at once. The limitation to four selections only is a drawback, that other visualizations compensate with a worldmap. Moreover, the tool sorts the selected countries alphabetically which does not allow to change the order of the countries and the geograohical location gets lost.

Other visualizations make use of scatterplots (Figure 2.3). This visualization is limited to four dimensions only. Each country is represented by a dot on the chart. The individual values for each dimension can be read from a country's position on the axis representing the dimension. It is hard to compare countries with this approach since it is difficult to compare information spatially. Furthermore, since there is a point representing each country and all countries are displayed at all times, it creates a visual clutter. One can easily lose track of a country while searching for another one. There is no possibility to allocate a country to something familiar that helps remember its values.

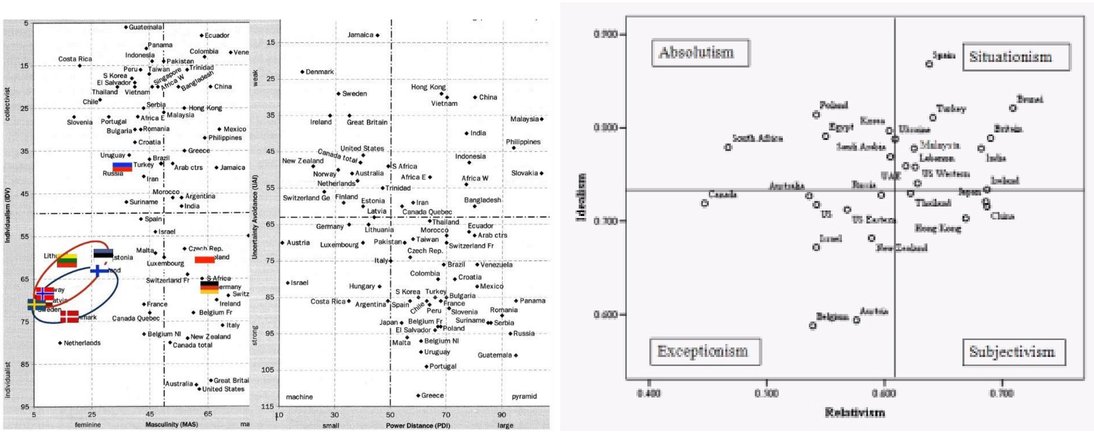

Figure 2.3: Visualization of the Hofstede Model with Scatterplots [McD08][sca]

The visualization of the GLOBE model consists of two parts. First, there is the worldmap where one can select a country by clicking on it. The selected country is colored in a dark purple, while all other available countries are colored in a lighter purple, as seen in Figure 2.4. This allows the allocation to a geographical position. The worldmap does not provide any more information. By selecting a country on the worldmap the data for the selected country is displayed below. Second, for each dimension a boxplot is created, on which the highest and lowest value as well as the mean value and the selected countries position is marked, as shown in Figure 2.5. This allows the comparison of the selected country with the average and determines the relative position to the rest of the data. Furthermore, the application also provides the visualization of cultures defined based on the data retrieved through the GLOBE project. Each so-called *group* is also represented

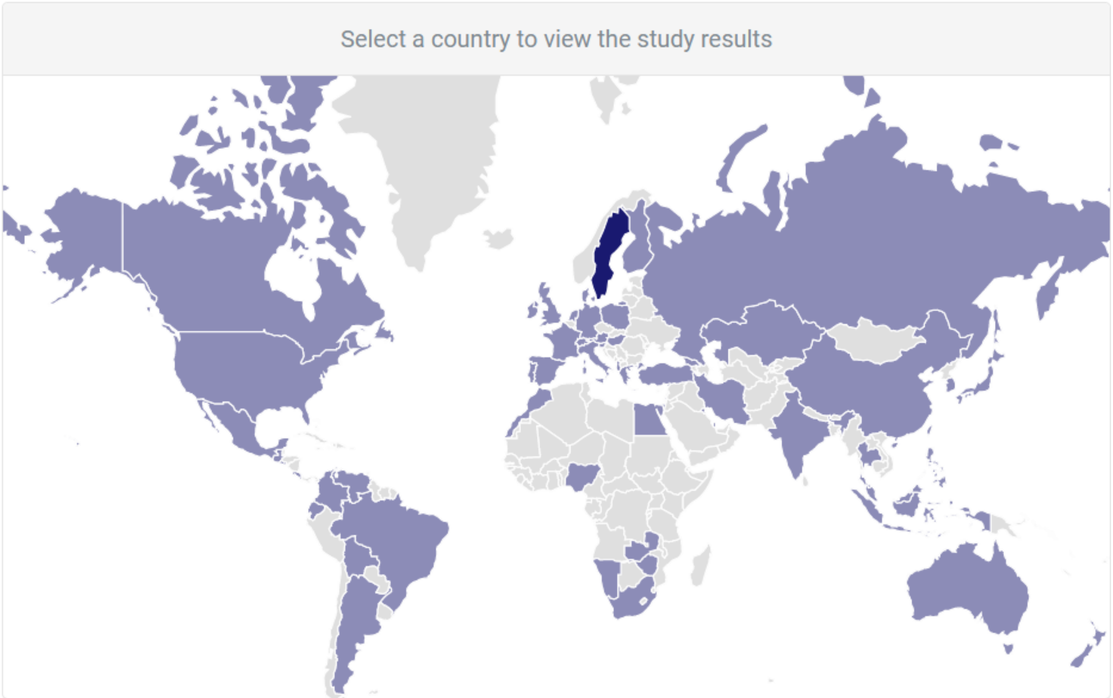

Figure 2.4: Visualization of the GLOBE Project with a Worldmap [gloa]

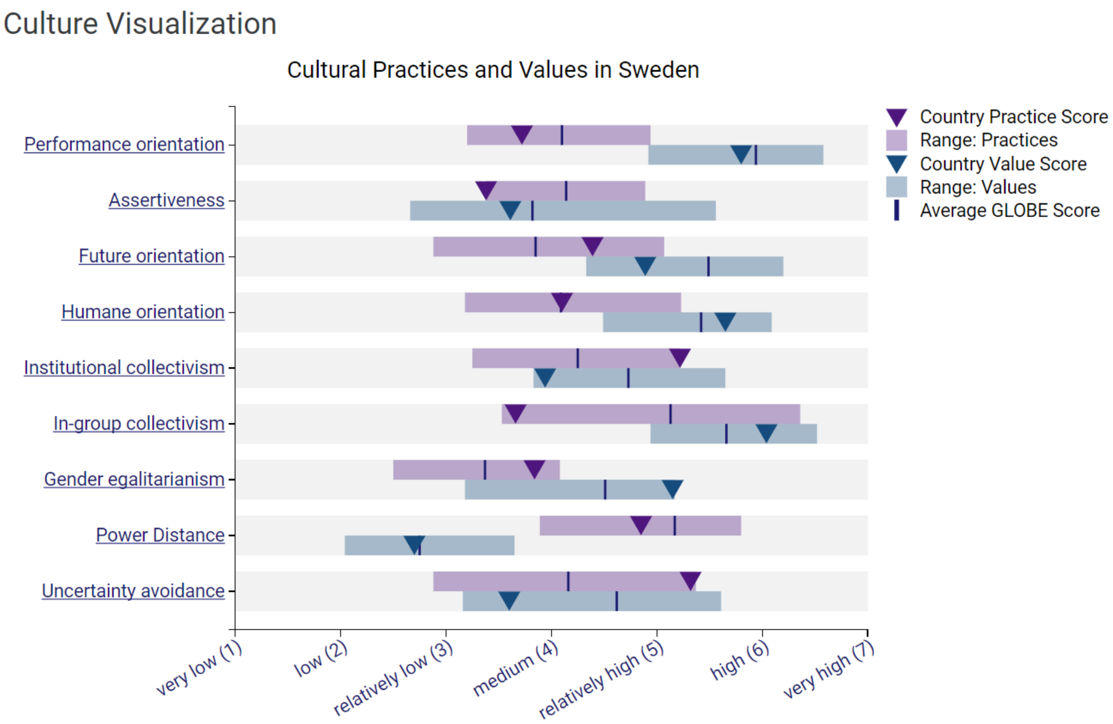

Figure 2.5: Visualization of the GLOBE Project with Boxplots [gloa]

with boxplots for each dimension and more textual information is provided. The groups are given different colors which makes borders visible and distinguishes between cultural regions, as shown in Figure 2.6. Averages are also available, as well as information on individual countries.

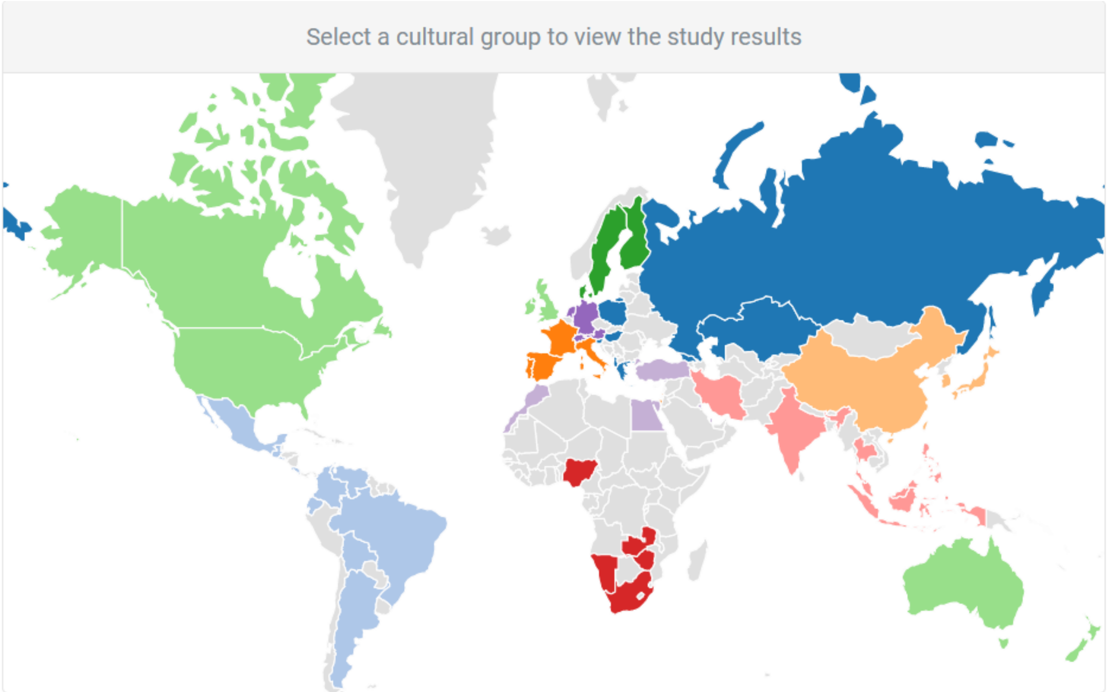

Figure 2.6: Visualization of the GLOBE Project Groups [glob]

CHAPTER 3

Methodology

The analysis of existing visualizations for cultural dimensions has shown advantages and disadvantages of current techniques, as discussed in chapter 2. We improve the advantages by rethinking their benefits and eliminate the disadvantages by changing the perspective and using new representations to visualize the data. We find that color is important to distinguish the data and be able to seperate information. Filtering the data is useful to crystallize information and focus on specific dimensions. The visualization should be connected to the geographical location, so it has a learning effect and one should always be able to see the scores to compare concrete numbers. We are interested in dealing with two main tasks:

1. Visualization of cultural dimensions (section 3.1)
2. Comparison of cultures (section 3.2)

as described in chapter 1. We hereby discuss how our framework addresses these two tasks.

3.1 Visualization of Cultural Dimensions

The visualization of the six dimensions should be compact, so as much information as possible is displayed at once. Furthermore, the addition of new dimensions should not only be possible, but also structured and expandable. With more dimensions added, the complexity of the visualization rises. The addition of another dimension must be easy and fitting to the existing structure of the previous dimensions. Previous considerations for this matter included starplots [War12], where for each dimension an axis would have been added, as seen in Figure 3.1. The use of starplots would have created a visual clutter very quickly due to the overlay of several dimensions. Furthermore, starplots would have

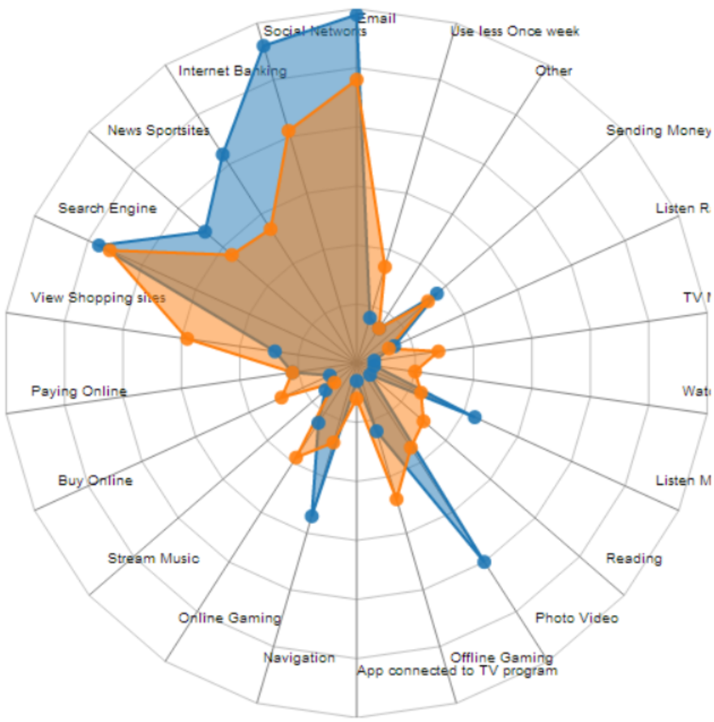

Figure 3.1: Starplot Example [rad13]

only been applicable to one evolution step and at most three countries at once, because for each evolution step added the amount of countries displayed gets added again and an additional axis must be added as well. For five countries and two evolution steps for instance, the visualization would overlay five starplots with four axes and another five starplots with five or even six axes, depending on the chosen evolution step.

Parallel coordinates [Ins85] were also taken into consideration to visualize the values of each dimension while maintaining the seperation of the evolution steps. Each axis would represent one dimension, similar to Figure 3.2. The evolution steps could then be represented by coloring the axes in different tones, which again would create too much colors and would prevent the use of colors from a scale for the values. Spatial seperation of the steps would have been a possibility but it would take up more space. The spaces between steps must also be wider so one is able to perceive them easily. Using more space would again create a large module and therefore not fulfill the requirements for the expected visualization.

Heatmaps [Fri09] allow an expansion of dimensions by simply adding a box to the existing ones, while staying very compact and well arranged. The heatmap used in the visualization consists of one row and six columns, where each column stands for one

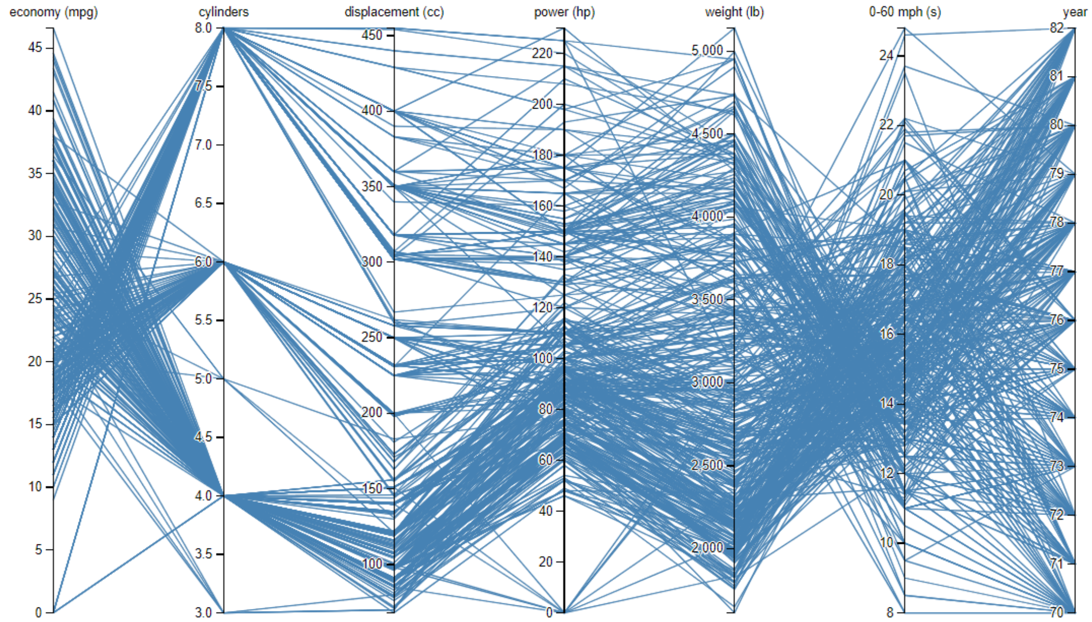

Figure 3.2: Example of Parallel Coordinates Using the Cars Dataset [Dav19]

of the dimensions defined by Hofstede [Hof11]. To visualize the three steps in which dimensions were added to the Hofstede model the space between the fourth and the fifth box as well as the fifth and the sixth is wider. An alternative to this approach, was to have different colorscales for each step of the evolution, which would entail the same limitations as the current use of different colorscales in the visualization of the Hofstede models. The first step of evolution, consisting of the first four dimensions were colored in a greenbased colorscale, the second step adding the fifth dimension had a red colorbase and the last step was colored in a bluebased colorscale. This approach was dropped due to confusion with too many colors. The solution of widening the space between steps is a more subtle visualization and the colors stay consistent. This is shown in Figure 3.3. The heatmap is colored with values from the colorscale defined previously and according

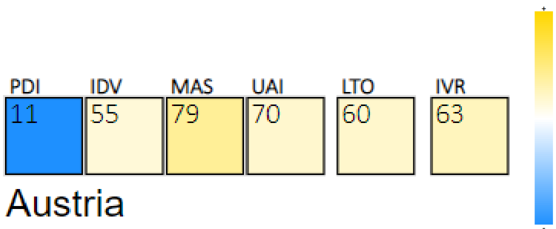

Figure 3.3: Heatmap with Larger Gaps

to the values for each dimension of the selected country. The labeling with the according values allows us to compare absolute values easily, since the heatmaps are aligned under each other. This way, the tiles are close to each other and both colors and values can be compared. For each country selected the program generates a heatmap, labeled with the country's name and the values for each dimension, respectively. The tooltip shows the dimension and value represented by a certain box.

3.1.1 Filtering and Selection

We want to be able to filter the data according to a certain country or contintent we want to explore. Therefore, an element, that filters the data and selects a subset is needed. Three dropdown elements, shown in Figure 3.4 define the selection of the dimension, country and continent. The dimension is selected by choosing one of the six possible

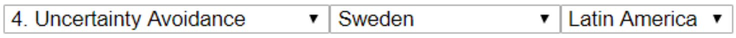

Figure 3.4: Dropdown Elements for Selection

values in the first dropdown. If a dimension was selected, the country selection adds the selected value to the selection and applies a color to the country on the worldmap. By choosing a continent all belonging countries are colored in an average value for the continent. Countries and continents are only colored, when a dimension is selected as well. Without a dimension selected the coloring is ambiguous. Changing the selected dimension reloads all selected countries and continents and colors them in their new colors respectively. Countries can be deselected and removed from the selection by clicking on them on the worldmap. The country will then be colored with the default color and removed from the selection.

3.1.2 Geographical Visualizations

To keep the perceived information in mind and use it to make instant comparisons, a familiar element combined with a universal colorscheme is introduced to the visualization. Previous visualizations, as described in section 2.3 did not make use of a universal colorscheme, an aspect that is crucial to new approaches as it delivers more depth, visual appeal and understanding as well as offers another dimension for comparison. The colors that are used are calculated by normalizing all values and interpolating on the defined colorscale. Normalizing the values results in having the same color for the highest and lowest value irrespective of the actual absolute value. This way, the highest value is always colored in "gold" and the lowest is always "dodgerblue", while the median is always "white". The normalization allows us to see a countries position by comparison to the other data. Furthermore, this approach enables finding correlations between dimensions. For instance, wherever power distance is low, the uncertainty avoidance might be high.

By defining a suitable, divergent colorscale (Figure 3.5) we introduce a pattern that is used in every element of the visualization. We use a divergent colorscale, because the data diverges from an extreme to a neutral state to an extreme. For the third dimension for instance we have feminity on the far left, neutrality in the middle and masculinity on the far right. The scale starts from "dodgerblue" to "white" to "gold". The default color is "lightgrey" and a selection without a value is colored in "silver". For countries without a value "black" and "red" were also taken into consideration. With "silver", non-value-countries are different from default values without being too dominant like "black" or "red". The colors are chosen in a way to also be dinstinguishable by colorblind

Figure 3.5: Colorscale employed throughout our Application

people. The colorscale is also displayed next to the worldmap so colors and relative values can be compared. By hovering over the colorscale the percentages are shown with a tooltip, which enables the comparison of relative values, by estimating the approximate color. By hovering over the countries on the worldmap the stroke changes to black. This emphasizes the selection and makes clear which field is being focused.

The color-encoded worldmap used in the visualization allows us to relate a country's values to its geographical location. This way the color, a new information, is combined with and connected to something familiar, the worldmap. Associating the colors to the geography is a good possibility to find correlations between the selected attribute and the location. A worldmap has the advantage that it brings something familiar to the visualization and reduces the abstractness of it. The map allocates each value to a form which is the country on the map and therefore creates a way to better memorize and perceive the values for regions. By selecting a country and a dimension, as discussed in section 3.1.1, the selected country is colored with the according value on the worldmap, which if available, is normalized and interpolated on the defined colorscale. Should there be no recorded value for the selected dimension, the country is colored in a silver, to visualize the selection. This way, we can see regional similarities as well as outliers of the chosen region or countries. The selection of a single continent colors all the belonging countries, with available data, with the average value and color of the continent. A heatmap is generated, displaying the average values and colors for the continent and labeled with the name and standard deviation. This function enables the comparison of different continents and their dimensions. By selecting a single country of the selected continent the country is colored in its own values and thus can be compared with the average value of the continent, as seen in 3.6. For some countries values are missing, which must be considered by the algorithm when calculating the average dimension values for the continents respectively. Changing the dimension regenerates all previous selected countries and continents and colors them in their new values.

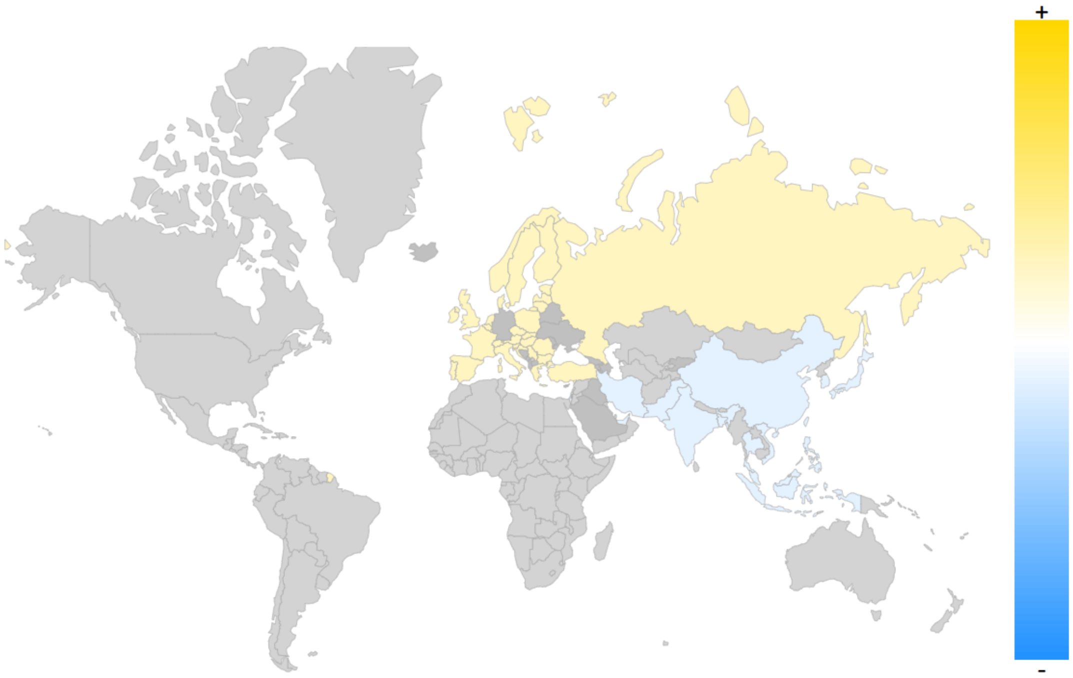

Figure 3.6: Worldmap showing Average Values for Asia and Europe

3.2 Comparison of Cultures

Since, there is no opportunity to visually compare the relative position of a country's score, a representation showing the actual difference between selected countries, is necessary. To visualize the spatial difference and emphazise the actual proximity between values, a chart similar to a hiveplot [Mar11] with one axis. A hiveplot usually consists of more than one axes and circles representing data that are connected with other axes (Figure 3.7). The one-axis-hiveplot consists of a line, that reaches from zero percent on the left side to 100 percent on the right side. For each selected country a circle is generated and displayed on the axis, according to its value for the selected dimension. The axis reaches from zero percent on the left to 100 percent on the right. The closer two circles are on the axis, the more similar they are in their values for the selected dimension. Each circle is colored in the according color from the colorscale defined. To distinguish the circles after selection, each is labeled with an abbreviation. To see the full name, while displayed a mouseover tooltip shows the full country's name. Figure 3.8 shows the one-axis-hiveplot in our implementation.

The addition of the one-axis-hiveplot allows the spatial comparison between values.

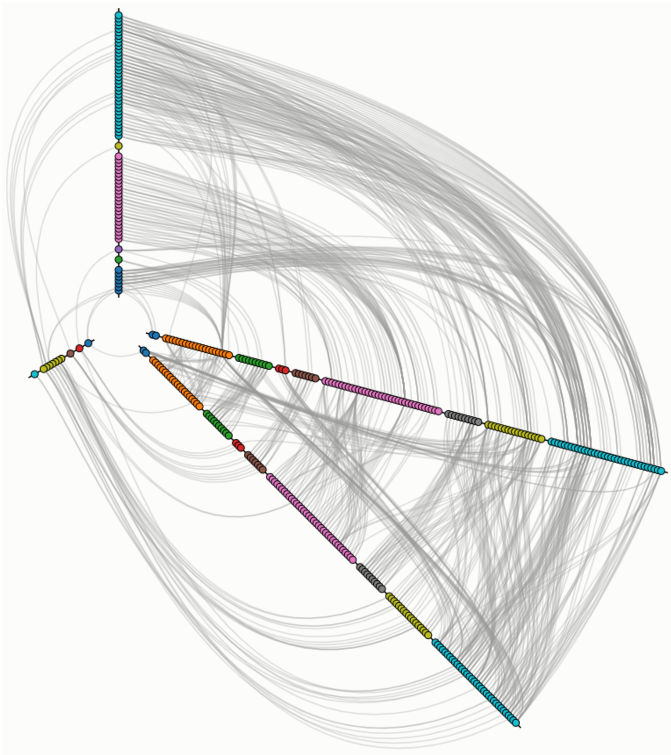

Figure 3.7: Example of a Hiveplot [Bos12]

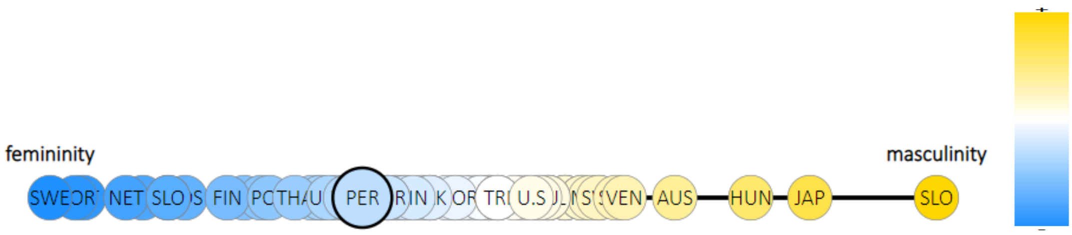

Figure 3.8: One-Axis-Hiveplot for Dimension 3

Smaller distances mean higher similarity. Higher distances mean smaller similarities between countries. Since the circles are not transparent, a disadvantage of this visualization is countries with the exact same value. Those are displayed above each other and therefore only one is visible at a time. For scores very close to each other, but not matching values, a mouseover bringing the circle to the front layer, as well as showing the country's name reduces this problem. The other elements of the visualization have so far not had a possibilty to see the actual similarity, since comparing two colors very close to each other is harder than comparing spatial locations. The heatmap shows the exact values and the worldmap shows the geographical similarities. The one-axis-hiveplot allows the direct comparison of these attributes.

Figure 3.9 shows the final user interface. The three dropdown elements are placed in the bottom right, while the worldmap is located to the left and dominates the view. The colorscale is added to the right of the worldmap, so colors on the map can easily be compared. The one-axis-hiveplot is placed below the worlmap. When a country or continent is selected, the heatmaps are added to the bottom of the page.

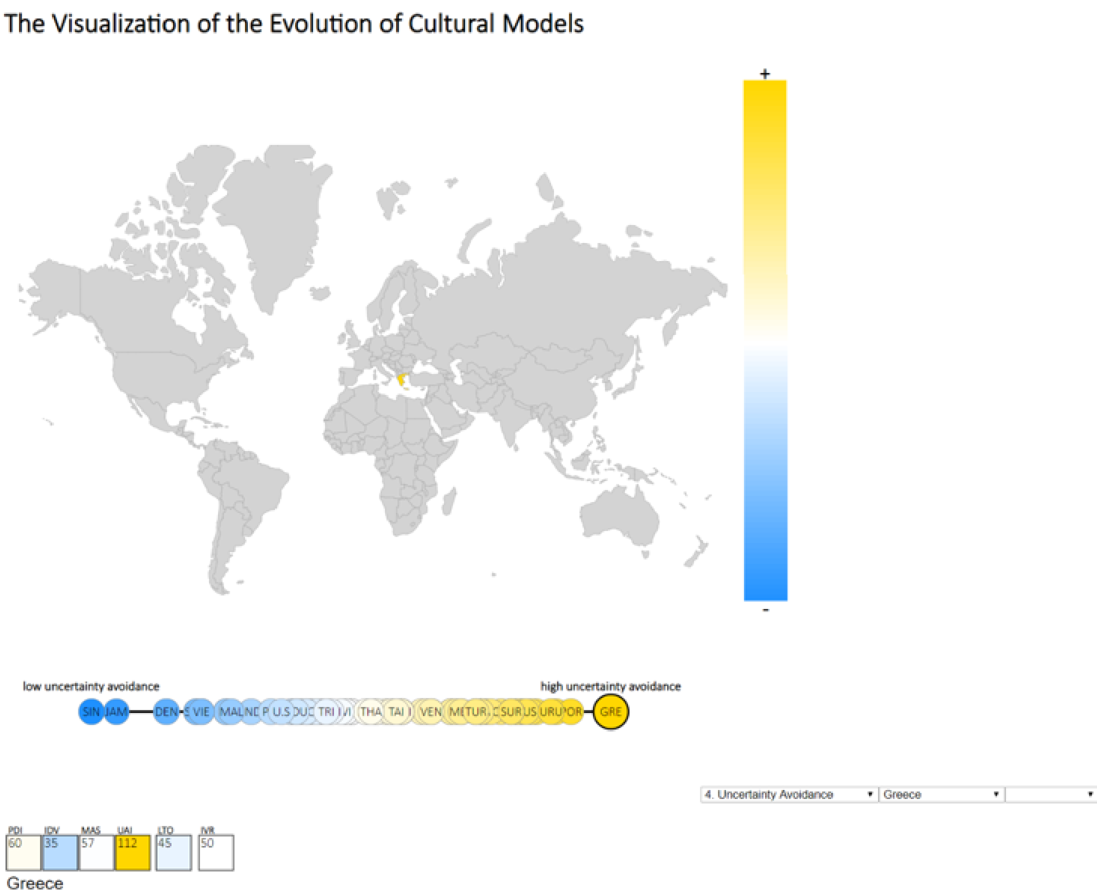

Figure 3.9: User Interface of our Implementation

CHAPTER 4

Implementation

4.1 Employed Technologies

The program is written in JavaScript and HTML and mostly based on D3. The development environment was JetBrains Webstorm [Jet]. The paper was written with TexWorks technologies [Sha].

4.2 Data Processing

The data is provided by the Geert Hofstede research [Hof15]. It includes six scores for 108 countries and country regions. The scores represent the country's culture consisting of the six dimensions defined by Hofstede et. al. [Hof11]: power distance (PDI), individualism or collectivism (IDV), masculinity or femininity (MAS), uncertainty avoidance (UAI), long term orientation or short term orientation (LTO) and indulgence or restraint (IVR). The values of the first four dimensions (PDI, IDV, MAS and UAI) are roughly within a scale from 0 to 100. Low values are found close to zero and high values are close to 100 but the highest and lowest values do not necessarily correspond to zero and 100. Whereas the last two dimensions (LTO and IVR) are exactly within the scale of 0 and 100. Dimensions 2 (IDV), 3 (MAS), 5 (LTO) and 6 (IVR) are not just one attribute but two, so higher values mean the opposing attribute while lower values imply the first listed value. Countries and dimensions for which no value exists are filled in with `null` values.

The data file `data_hofstede.csv` is arranged in eight columns and 109 rows. A header row labeling all columns is followed by 108 rows of data for each country. The six columns containing the dimension values are added to one column with the countries' full notation (country) and a column containing three-letter IDs for each entry (ctr). These IDs and notations are used to identfy and find countries throughout the program. To allocate the countries' data to the worldmap all data is assigned to a numerical ID defined by the worldmap used. The mapping is saved to the `mapping_countries.csv` file and accessed whenever an interaction with the worldmap needs data. The file was created by allocating the worldmap's IDs manually to all available countries from the data file. It is arranged in three columns for each country, consisting of the country's name (country), the three-letter ID (ctr) and a numerical worldmap ID (ID). The program reads and processes the data from `.csv` files.

4.3 Calculations

To use one uniform colorscale for all dimensions, the values have to be normalized and aligned to the defined colorscale. The values are normalized with a min-max-normalization [Ras14] also known as rescaling.

$$x_n orm = \frac{x - min(x)}{max(x) - min(x)}$$

For this operation when reading the data, the minimum and maximum value of each dimension is saved to variables and later accessed by the `normalize()` function when calculating the normalized values.

The normalized values are then passed to the colorscale defined globally as a parameter. This call returns a colorvalue depending on the normalized value. The function provided by D3 `d3.interpolate()` enables the interpolation between the selected colors. In this case the interpolation of colors starts with "dodgerblue" at 0, "white" at 0.5 and "gold" at 1. Values between 0 and 0.5 will return "dodgerblue" with varying hue values and values between 0.5 and 1 result in "gold" with varying hue values. Interpolating between three colors means to interpolate between two colors but distiguishing between values of the first and second half. In this case values bigger or smaller than 0.5. A normal color interpolation within two colors is calculated with

$$Cr = Ar + (Br - Ar) * t$$

[Mic18] where Ar stands for the start color, Br stands for the end color and t is the normalized value, that defines the percentage of the scale. For the first half of the colorscale used in this visualization the start color is "dodgerblue" and the end color is "white", as for the second half the scale starts on "white" and ends on "gold".

To display the data on the one-axis-hiveplot, not much calculation is needed. The circles are simply displayed on the axis by their normalized value. Values close to zero are positioned on the left side of the axis. Values around 0.5 are close to the middle of the axis and values close to one are displayed to the right.

4.4 Core Application

4.4.1 Visualization of Cultural Dimensions

The heatmaps are created by adding rectangle elements provided by D3 to a prior declared SVG element. The function `.append(rect)` adds a rectangle for each dimension with the corresponding color calculated beforehand, passed to the function `drawCalendar()`. Each rectangle is labeled with the abbreviation of its dimension stored in `dimensionsABBR` and applied with `.append(text)` as well as the actual value of the dimension which is passed as a parameter and applied in the same way. By using the function `.append(title)` and passing the dimension and value to the element with `.text()` a tooltip that shows the full name and value of the dimension is added to each rectangle.

Filtering and Selection

The selection elements are implemented as shown in Figure 4.1. The values for the

```
var selectDimension = d3.select('body')
    .append('select')
    .attr('class', 'select')
    .on('change', onChangeDimension);

var dimensionOptions = selectDimension
    .selectAll('option')
    .data(dimensionSelection).enter()
    .append('option')
    .text(function (d) {
        return d;
    });
```

Figure 4.1: Implementation of the Dimension-Dropdown-Box

dropdown element are stored in an array which is then passed as data to the append function `.append(option)` of the `.append(select)` element. All dropdown elements (*dimension, country and continent selection*) are implemented in this way.

Geographical Visualizations

To generate the worldmap first a projection has to be created (Figure 4.2). This is done by using the D3 function `.geoMercator()`, which determines the projection of the map. There are other functions provided by D3 that create different projections or generate maps for a single country only [d3P]. Here, we also scale, rotate and translate the map with the corresponding functions `.scale`, `.rotate` and `.translate` to adjust it to the page. The projection is then passed to the path via the function `d3.geoPath().projection()` which then is used as an attribute for the previously

```
var projection = d3.geoMercator()
    .scale(130)
    .rotate([352, 0, 0])
    .translate([width / 2, height / 1.5]);

path = d3.geoPath().projection(projection);
```

Figure 4.2: Declaration of a Projection for the Worldmap

created SVG `mapSVG`. The data of the `mapSVG` is retrieved from the extension *topoJSON* as seen in Figure 4.3. Moreover, the worldmap is provided with functions called when

```
.data(function (d) {
    return topojson.feature(world, world.objects.countries).features
})
```

Figure 4.3: Retrieving Data for the Worldmap[unp]

either hovering over or clicking on elements of the map. The function `.on(mouseover)` changes the stroke of the selected country to black and widens it, so it is clear, which country is selected. To reset the changes made to the stroke by the previous function the `.on(mouseout)` sets the values to the default settings again. To remove countries from the selection after selecting them from the dropdown elements, one can click on the country on the map. The function `.on(click)` removes the country from the selection by calling `removeSelectedCountry()` and passing the retrieved ID. `removeSelectedCountry()` loops through the mapping file and finds the correct country name for the ID passed to the function. After finding the ID it checks if the country is already selected and if so removes it.

The colorscale is often accessed from different modules of the visualization. It is declared in the HTML file. This way it can be accessed globally. As seen in Figure 4.4 we use the provided function `d3.scaleLinear()` to calculate the scale with a linear interpolation. The `.domain` attribute is an array that sets the numerical value range of the colorscale,

```
var minColor = "dodgerblue";
var maxColor = "gold";

var colorScale = d3.scaleLinear()
    .domain([0, 0.5, 1])
    .range([minColor, "white", maxColor]);
```

Figure 4.4: Implementation of the Colorscale

whereas the attribute `.range` sets the color range by passing an array with the same length. Here, the first value of the domain array (*0*) corresponds to the first color of the color array (`minColor`). The minimum color and the maximum color are stored in the variables `minColor` and `maxColor` and set as "dodgerblue" and "gold". By passing a value within the range of the previously defined domain array to the colorscale, as seen in Figure 4.5 a color according to the scale is returned. The maximum color is returned

```
function calculateColor(normValues) {

    var colors = [];
    var defaultColor = "silver";

    for (let i = 0; i < normValues.length; i++) {
        if (Number.isNaN(normValues[i])) {
            colors[i] = defaultColor;
        } else {
            colors[i] = colorScale(normValues[i]);
        }
    }

    return colors;
}
```

Figure 4.5: Function Calculating the Colors

when passing the last value set in the domain array and the minimum color is returned when passing the first value of the domain array. As there is a second value set in the domain and range array, passing the second value (*0.5*) to the colorscale will return the second color (*white*).

4.4.2 Comparison of Cultures

To create the one-axis-hiveplot we generate a simple SVG. By adding a circle and text element to `.append(g)` we generate a circle element with text applied to it. These elements can be then called and accessed as one. The circles are created with a larger radius and black and thicker stroke for selected countries. As in previous modules a mouseover tooltop is added.
As the one-axis-hiveplot displays circles for each country at all times, the circles can overlap and thus are not visible at all times. To fix this problem the function `.on(mouseover)` applied to all `g` elements sets the parent-child-relation by calling the function `.appendChild()` on the current `parentElement` and sets the current object as the child, as seen in Figure 4.6. This way by hovering over a circle on the one-axis-hiveplot the circles is moved to the front and becomes fully visible.

```
g.on('mouseover', function() {
        this.parentElement.appendChild(this);
    })
```

Figure 4.6: Bringing an Element to the front Layer

CHAPTER 5

Results

This chapter will discuss a few findings that are achieved using our implementation.

5.1 Comparison of Two Predetermined Countries

The visualization allows us to compare two or more countries and continents with each other. Moving to another country can be very exciting. For an exchange year in Stockholm we want to compare Austria and Sweden with each other. Using this example we will show the main feature of the comparative visualization.

The heatmaps for Sweden and Austria (Figure 5.1) show, that they are very similar in the fifth dimension, where Austria has a score of 60 and Sweden a score of 53, which means both countries tend towards a short term orientation but are rather balanced between long and short term orientation. We can also see that both countries have a low power distance and lean towards individualism as well as indulgence, meaning they have a low acceptance of the occupation of higher positions by others, take actions primarily in their own interest and are rather open to foreigness.

The one-axis-hiveplot emphasizes on Sweden's and Austria's similarities. The small distance between the large circles on the axis show similar values. Austria holds the lowest value in power distance, which is determined by the large circle displayed on the far left on the one-axis-hiveplot. This means there is no other country measured with a lower power distance and Austrians tend to keep away from higher positions and prefer decentralization. Sweden has the lowest value for masculinity, which means that Sweden is very feminine as a culture. This results in a very weak role seperation between men and women, as well as the admiration of the strong and disdain of the weak. The countries are the most different in this dimension, with Austria having the fourth highest score, as seen on the one-axis-hiveplot (Figure 5.2). Only Hungary, Japan and Slovakia have higher scores.

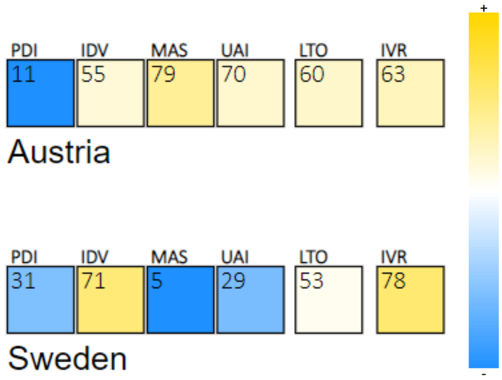

Figure 5.1: Heatmaps for Sweden and Austria

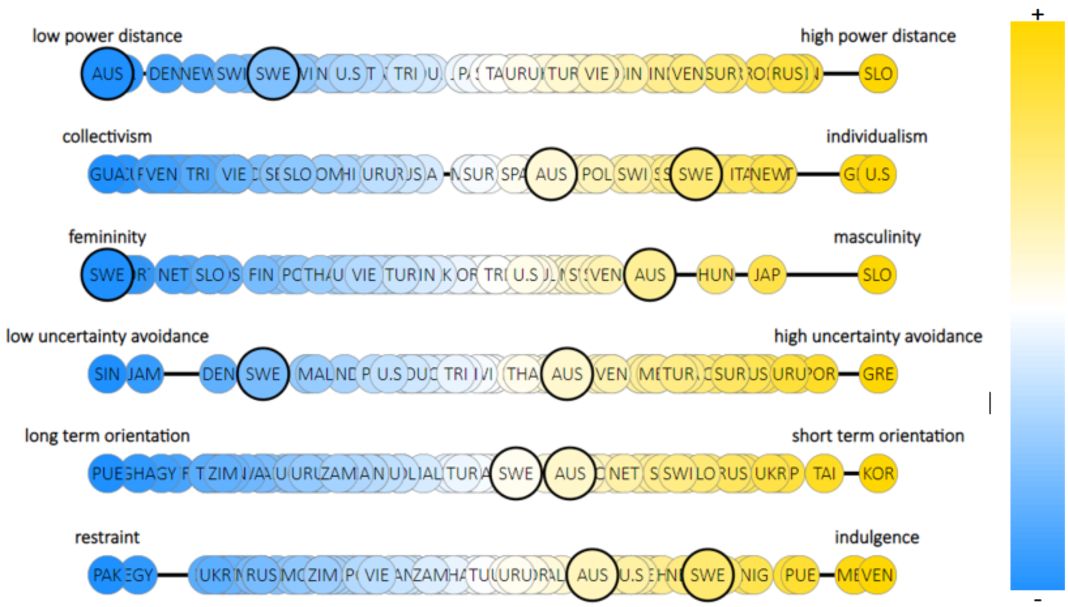

Figure 5.2: One-Axis-Hiveplots with Sweden and Austria selected

The worldmap shows the geographical location of both countries and emphasizes on their differences and similarities (Figure 5.3). By using the continent selection we can compare Austria's and Sweden's scores to the average European value. This feature is closer discussed in section 5.2.

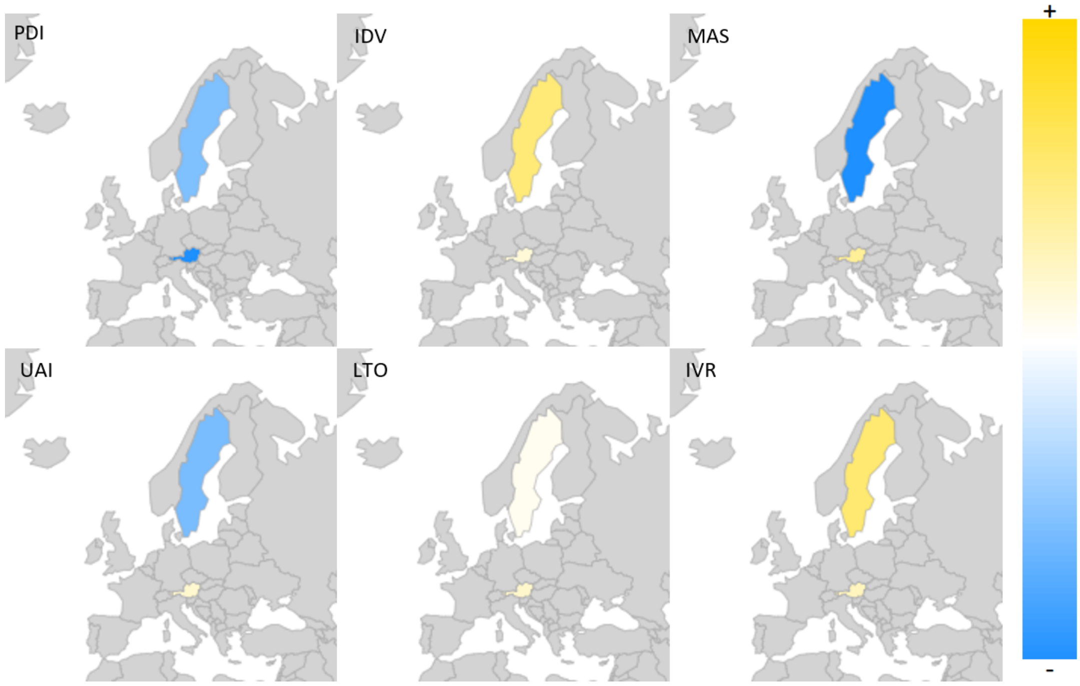

Figure 5.3: Worldmap with Sweden and Austria selected

5.2 Exploration of Countries and Continents

Displaying all the continents and regions of the world with the application lets us define cultural regions. Similar values can be observed in different parts of the world. Having a familial origin in another culture can mix up different values. By using the visualization we can define these differences and analyze them. Using the example of the middle eastern and oriental as well as the central European culture we will demonstrate this feature of the application. Selecting the continent of Asia and Europe as well as the countries Austria and Iran creates the worldmaps as seen in Figure 5.4. We see that Europe and Asia do not have many similarities. They are diverging in power distance, individualism and uncertainty avoidance and are rather different in masculinity and long term orientation as well. Only the sixth dimension shows a small similarity as the colors are close to each other. We can see that Austria is an almost exact match to the average European score in the second, fourth and fifth dimension. Furthermore, we find that Iran is always very different to the average Asian score. In the sixth dimension

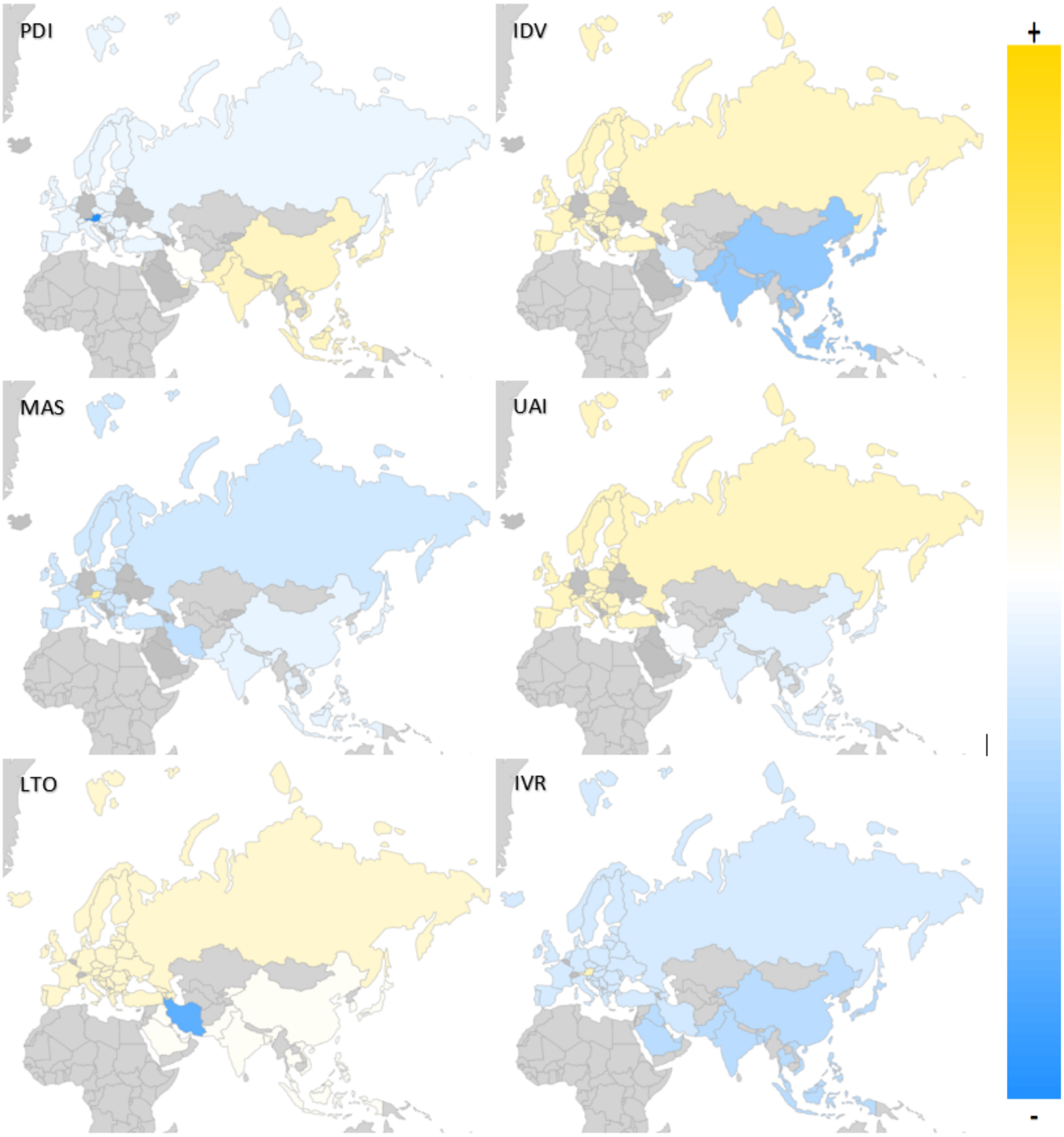

Figure 5.4: Worldmap showing Europe, Asia, Iran and Austria

Iran's score is even closer to the Europan average than to the Asian. However, it is still rather different to the Austrian score. Iran and Austria are the most similar in their uncertainty avoidance. Apart from that there are not many similarities. The heatmaps of the the selected continents emphasize on the differences between Asia and Europe, as seen in Figure 5.5. Considering the standard deviation, Asia and Europe overlap in all

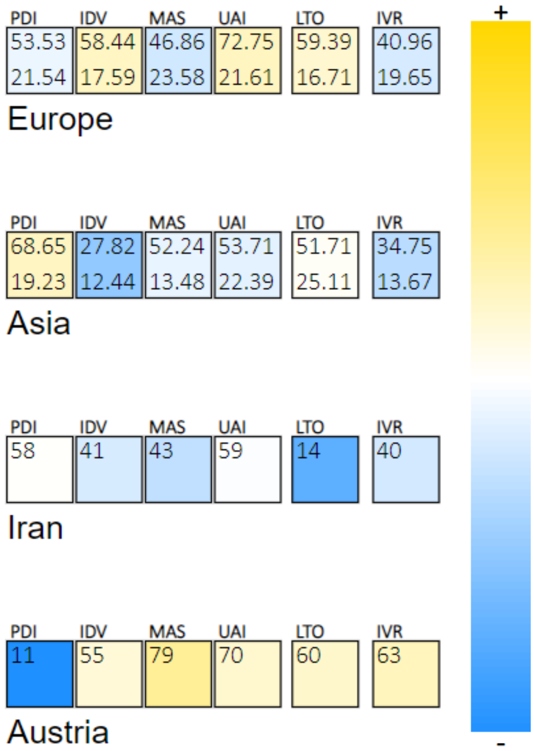

Figure 5.5: Heatmaps for Europe, Asia, Iran and Austria

dimensions but one - individualism. Asian countries seem to be more collective, while European countries tend to be more individual, meaning Asian societies tend to make decisions by considering the affects to their surroundings as opposed to taking actions primarily in the own interest.

5.3 Unusual and Unexpected Findings

The visualization can not only show similarities and differences but also comes in handy when finding unusual information and unexpected scores. Figure 5.6 shows the power distance scores for each available country on the worldmap. Interestingly, there seems to be no correlation between the power distance scores and a country's geographical location. Especially in central Europe we see that there are very different power distance scores are clot together. Austria with the lowest PDI score is located next to Slovakia, the country with the highest PDI score and the Czech Republic is exactly in the middle of the

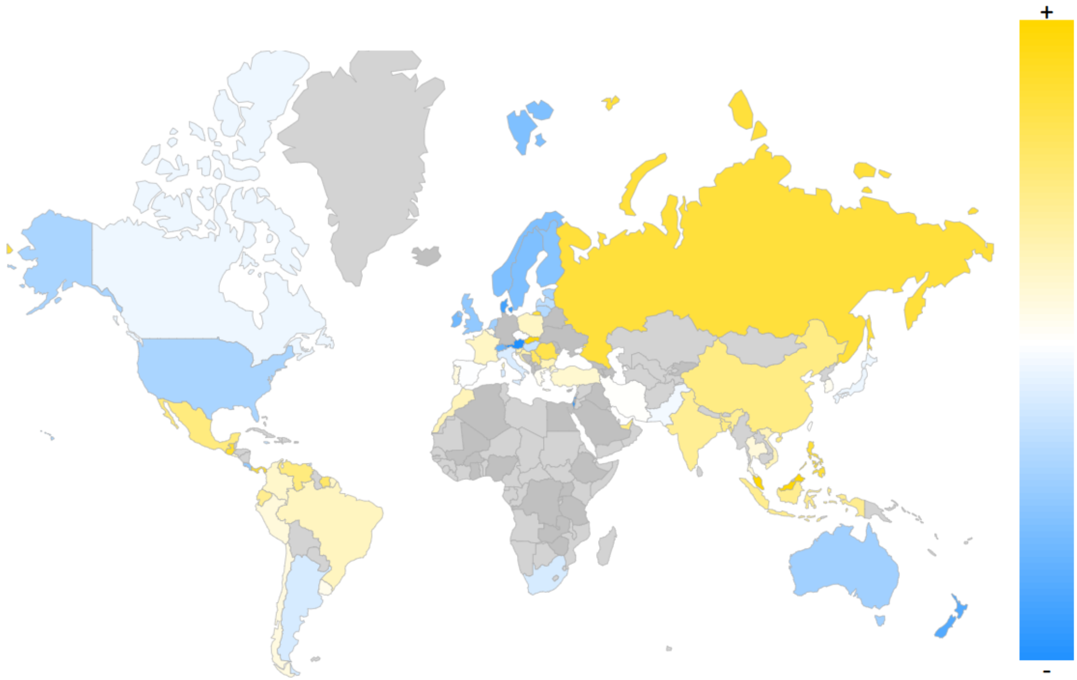

Figure 5.6: Worldmap colorcoded for Dimension 1

spectrum, which the white coloring shows. Moreover, in Latin America we see Argentina is the only country with a low PDI score in South America and next to Costa Rica the only country in Latin America with a PDI score in the blue region of the colorscale. As seen in Figure 5.7 the uncertainty avoidance scores somehow show regional similarities. There seems to be a stripe of high scores in this dimension starting from Latin America including northern Africa, central and southern Europe and Russia. The rest of the world has rather low UAI scores. In the heatmaps of Great Britain and India with additional information from the average values for Asia, shown in Figure 5.8, we can see that history also plays a role in cultural models. As a colony of Great Britain, India shows strong similarities in many dimensions. Both countries have the exact same LTO score and are very similar in their MAS and UAI scores. The scores for the other dimensions are simply explained by taking the average Asian scores into account. India's PDI score conforms with the averages Asian score and the IDV score seems to be a mixture of Great Britain's high score with the Asian influence of a very low score. Similarly, India's IVR score can be explained.

Considering recent events happening between Mexico and the United Stated of America it is interesting to see, that both countries actually have commonalities. As seen in Figure 5.9 both countries are very different in their power distance, individualism and uncertainty avoidance but on the other hand are very similar in their MAS, LTO and IVR scores. Mexico and U.S.A. have very low LTO scores, meaning both are very long term oriented. Interestingly, both countries are very indulgent, which generally means a

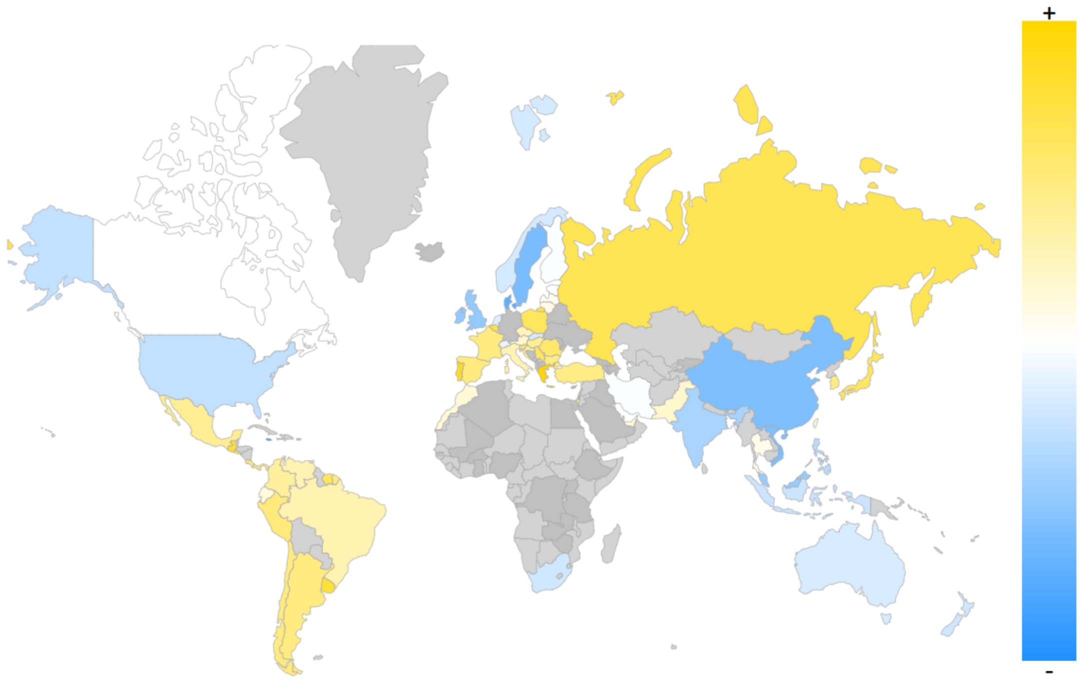

Figure 5.7: Worldmap colorcoded for Dimension 4

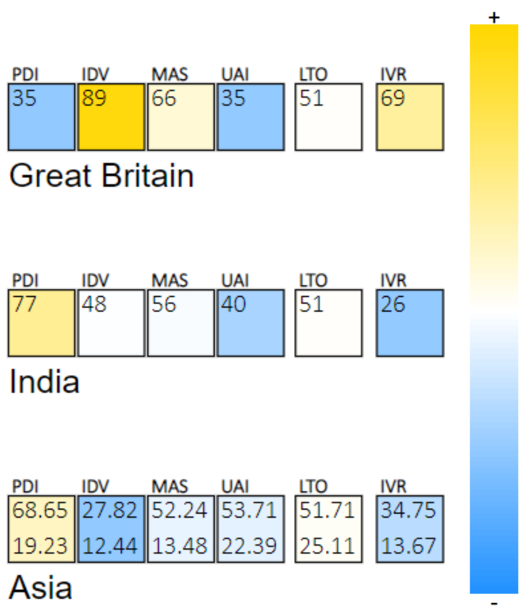

Figure 5.8: Heatmaps for India, Great Britain and Asia

high acceptance of foreigness.

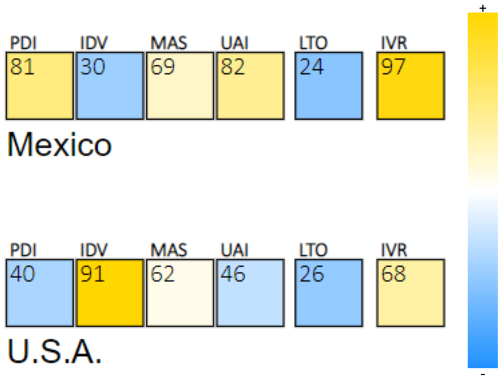

Figure 5.9: Heatmaps for U.S.A. and Mexico

CHAPTER 6

Conclusion and Future Work

Visualizing cultural models requires more than one module to fully understand the data. By using D3 and its functionality we were able to create a visualization focusing on different aspects and implement more than one feature. Our visualization enables the visualization of geographical locations and the comparison of different cultures and continents.

For future work we can focus on more details regarding the data, like adding and processing the small countries not displayed on the map and merging the data for ambiguous data like Germany East and Germany. Moreover, there is still space for improvement regarding the interactivity with the visualization elements. Focusing on the interaction with the worldmap and implementing selection via the map itself can easily improve the visualization. In addition, the time evolution of cultural models can be highlighted even more, by adding animations and capsulating the steps of the evolution.

In conclusion, the visualization of cultural models gives a good insight on how cultures are structured. Countries which are far apart from each other and are expected to have no similarities at all, are more similar than one might think. The visualizations enables to find these similarities and make assumptions upon these findings. Wherever cultural models find application, the visualization is also helpful and in some cases even necessary. Cultural models and correlations based on the findings have applications in economics, marketing and integration. In all these departments visualizations help to better understand the sole data retrieved from various studies.

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