Time to Combat Climate Change

Motivation

Winter is coming. Despite the emphasis on the importance of the climate change issue is becoming a cliché to some extent, we may still be inadequately prepared for this problem, and one of the significant reasons is the naivety and ignorance of human society.

Never before has there been an issue that so closely interlinks the destinies of humanity, and even all life, as climate change. No matter it's New York or Tokyo, the rising sea levels have observed the consequences of decades of industrial production. No matter it's London or Rio de Janeiro, extreme weather events have shown massive destructiveness. Faced with the potential for war and catastrophe it may bring, everyone should find ways to act. Addressing the global crisis brought by climate change is an international issue, while the prerequisite for cooperation is consensus, where information visualization can definitely play a role. Information visualization can honestly reveal the thrilling stories hidden behind data, which is what we should immediately begin to act.

Overview

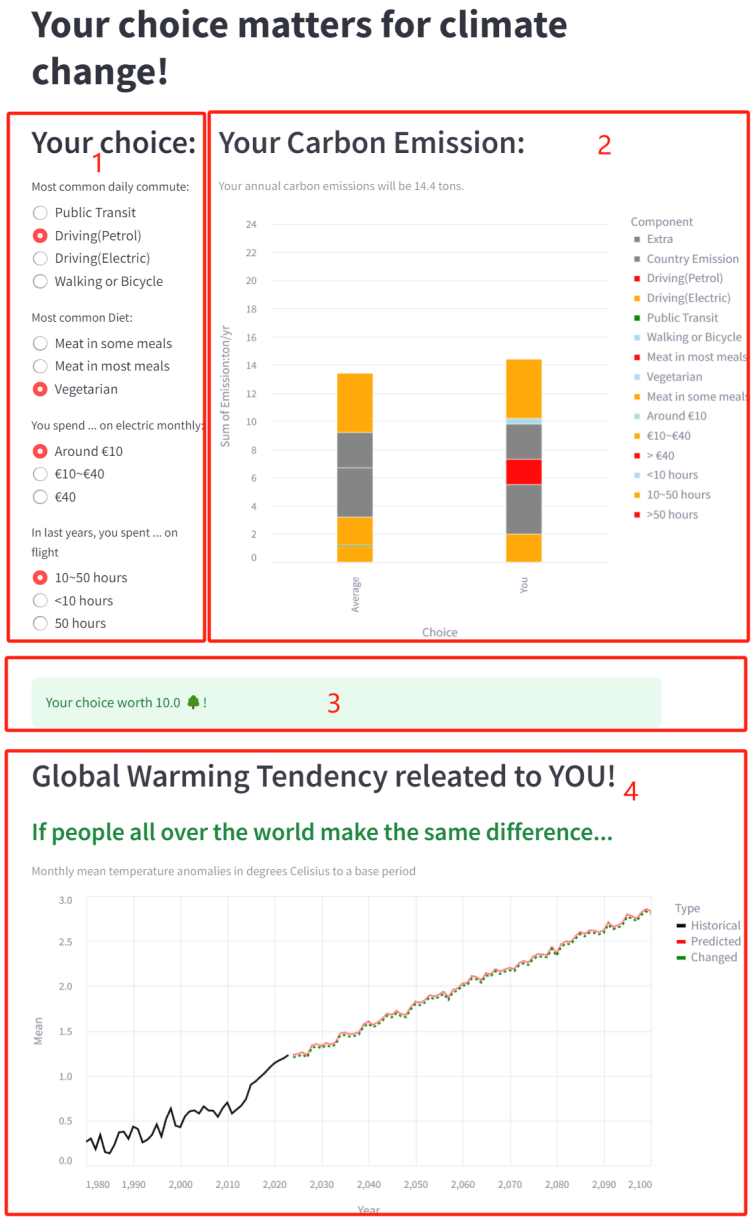

Figure 1 Overview of the project

As illustrated in Figure 1, the visualisation project is served as a web page and can be roughly divided into four sections.

1. An option box, consisting of four radio options, which investigates the viewer's daily commuting/eating habits/energy consumption and long-distance travelling. These aspects constitute the main part of the personal carbon emissions.
2. Personal carbon emissions. Two stacked bar charts visualise the estimated carbon emissions of the audience and the average. Each bar chart consists of multiple parts that can be changed in real time depending on the options.
3. Variable information, converting the different carbon footprints of the audience options directly into a number of trees.
4. global warming trends. Shows historical data, projected data and a better future with energy saving options.

In the following parts, I will give details about the methodology and description.

Related work

There are many calculators for personal carbon footprints available on the Internet, with research questions similar to this one, but with various shortcomings in comparison.

1. Dependence on inputs or questionnaires: Some projects aim to make detailed calculations of personal carbon emissions, such as Footprint Calculator [1], Myclimate calculator [2], United Nations Carbon offset platform [3]. However, while collecting detailed data, users also need to spend more time on input, which hinders the possibility of further experience. In addition, it may be difficult to memorise some of the numbers, which in turn compromises the accuracy. In contrast, My Carbon Footprint[4] does a little better, using bar and combo tabs for selection - but there are still too many.

   In contrast, my project uses only a combination of radios, which allows the user to enter data at minimal cost. It's true that precision is lost, but it's enough for the user to clearly enter and see the changes!

2. Lack of more direct transformation of results: Yes, I can reduce my carbon emissions by 2 tonnes per year by doing this, so what? Abstract numbers tend to confuse the audience, whereas concrete results are often more inspiring. In my project, the different options give direct feedback on all the information presented, which greatly enhances the presentation of the theme.

Methodology

In the original plan, the visualisation results were to be divided into two main parts: those responsible for visualising the spatial elements of the climate change crisis and those responsible for visualising the dynamics of the climate change crisis. In the final implementation, the main visualisation results are still divided into two parts, but there are differences in many implementation details. The details and comparisons are described below.

Approach 1

Design

In the original design, the first part was mainly responsible for visualising the spatial elements of climate change, i.e. revealing that it is a global problem. Using the Earth as a setting and the species as characters, a story of conflict is told. How unintentional everyday behaviour affects carbon emissions, and how these emissions can have a long-term impact on the ecological chain in the form of extreme weather events. This makes it easy to connect everyday minutiae to major issues through inspiring stories that can truly build consensus and positively impact the issue of climate change. We believe that even someone who has never travelled more than twenty miles from their home town will recognise the importance of choosing a more environmentally friendly and energy efficient lifestyle when they see how their daily life is quantified as a carbon emission - and how such a carbon footprint can cause climate change that can lead to catastrophe on a global scale.

The design goals included simple interactions (e.g. tapping a bottle of Coke on the screen), a distinctive style (highly recognisable icons) and then seeing the impact of the quantified data and presenting a visualisation of how this is changing the climate. The interaction of the visualisation process takes less than five minutes from the user's action to reading all the results.

Implementation

In our actual implementation, we achieved most of what we had originally predicted. The biggest difference, however, is in the results. Whereas the original goal was to have a static result in the form of a stylised map, in our implementation it was mainly achieved by a stacked bar chart. I thought long and hard about which format to use: the world map format looks very fancy, but too many subjects and objects are often confusing and hinder the transfer of information; instead, a simple and straightforward bar chart would achieve this goal.

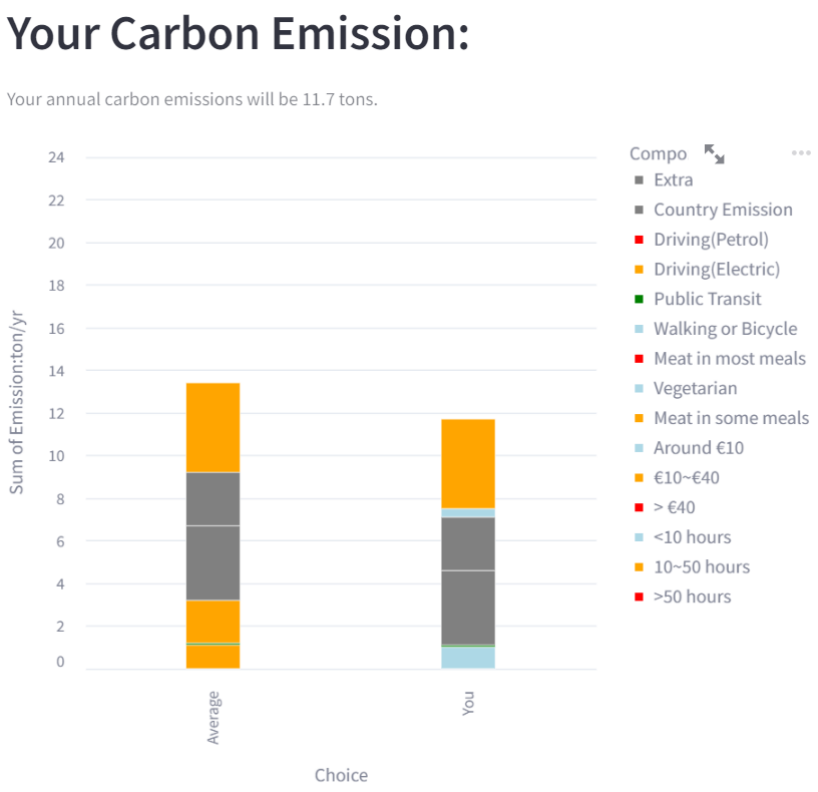

Figure 2 The stacked bar chart of Carbon Emission

As shown in Figure 2, the chart consists of two bars, the average carbon emission bar chart and the barof carbon emission data corresponding to user options. Each bar consists of five parts, namely Extra, Country Emission, Commute, Diet, Energy Consuming and Trip. Among them, Extra and Country Emission are fixed carbon emissions that cannot be changed, while the rest of the parts dynamically generate a new figure with the change of user's options. The remaining sections dynamically generate new images as user options are changed, reflecting higher or lower carbon emissions totals. This is a straightforward way of relating the user's daily life to the abstract numbers of carbon emissions. It is worth noting that within each category, greener options tend to correspond to lighter colours, which is more intuitive. A trick we used in the data processing was to use the electricity bill and the total duration of the flight to calculate the energy consumption and the carbon emissions of the flights taken, respectively, to better assist the user in inputting the figures and at the same time create awareness of the need for estimation in their daily lives, which is a win-win situation.

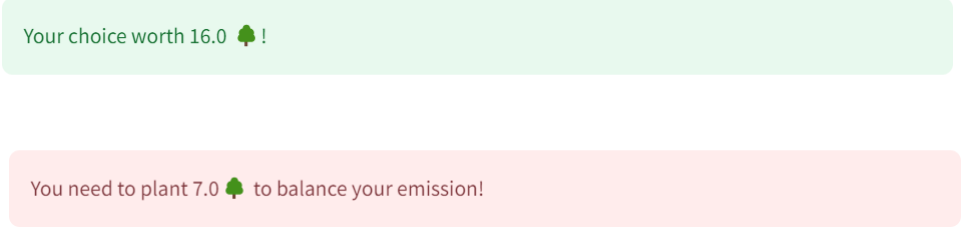

Figure 3 The message transforming carbon emission to trees

We used different coloured messages to provide instant feedback on each change made by the user, as Figure 3. When a user chooses a more carbon-emitting lifestyle, a red message box reminds the user how many trees need to be planted in order to balance the decision; conversely, when the user prefers a more eco-friendly lifestyle, a green message box congratulates the user how many trees this decision equates to. The use of emoji symbols in the message box achieves a stronger representation.

Approach 2

Design

In the original plan, this section hoped to apply information visualisation to demonstrate the dynamic nature of the climate problem, to reveal potential crises and solutions, and to include stories that could be compelling. In this way, we can make more people aware of the urgency of the climate crisis and engage in discussions about solutions, ultimately leaving a sustainable environment for future generations. We believe that when users see the dynamic presentation of the results, they will intuitively understand how their actions will have an effect and how they can make more informed choices. In the plan, users will interact dynamically with the results by making their own choices and reading them.

In the actual implementation, most of the design goals were accomplished as well. One difference is that instead of using animation or video as originally conceived, I used a line graph comparison. This change was not only for technical reasons, but also because static charts give the viewer the opportunity to make their own decisions, to divide their attention according to their own interests, rather than just following the designer's ideas. In addition, by comparing different line charts, the user can still achieve dynamic interactive effects, even more precise.

Implementation

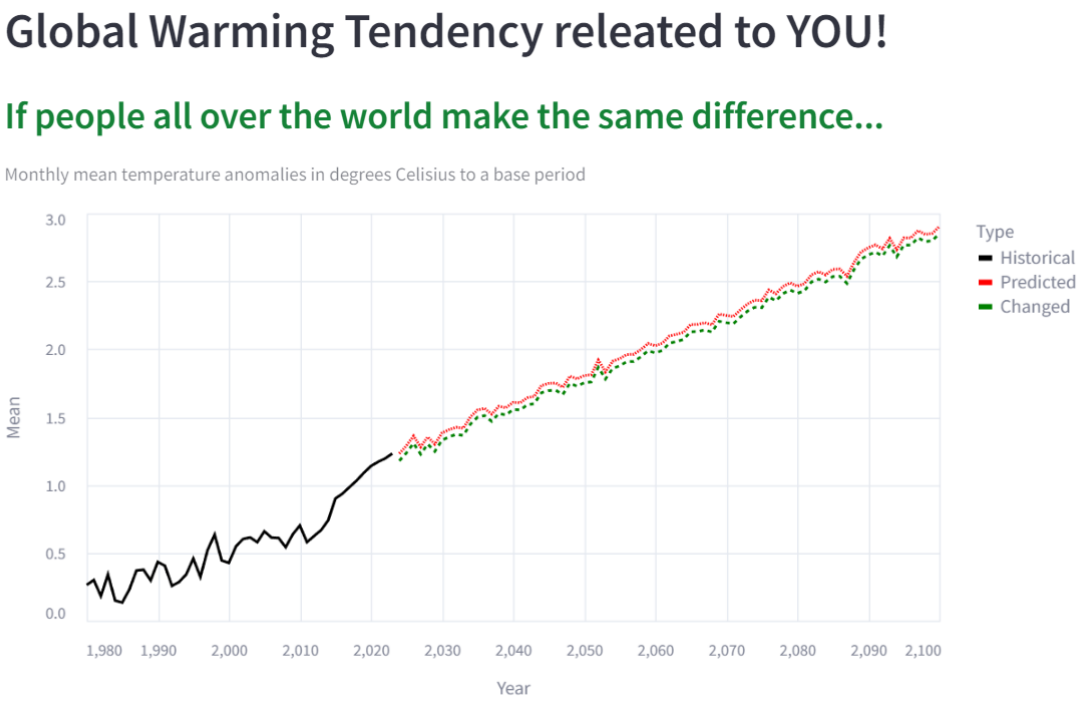

Figure 4 Monthly mean temperature anomalies in degrees Celisius to a base period

As shown in Figure 4, this graph shows the extent of temperature deviation from year to year. The graph consists of three parts: historical data, forecast data and changed data. The historical data is based on real observations, and the projected data is derived from the predictions of the relevant scientific institutions and is represented by the black colour, which symbolises immutability, and the red colour, which symbolises crisis, respectively. The data represented by green shows us a promising future: when a user makes a decision to be more environmentally friendly, the green line shows how our future could be different if everyone in the world made similar changes. With the contrast between the red and green lines, it's even better than an animation for communication. The graphic perfectly combines the elements of time and space and provides the visualisation in an interactive form: if people around the world work together, we can achieve a lot in the coming years - and the change starts with YOU! The user will be secured to be involved, which will definitely contribute to the whole world. The style of the dotted lines reveals the fact that they are not yet realised, but they also leave us in the action.

Tools and data

In the previous design, the visualisation effect will be mainly achieved by JavaScript-based open source tools, such as D3, TopoJSON] and ndjson-cli. However, in the actual implementation, I found that the encapsulation of a high degree of visualisation platform is either difficult to achieve the effect of customization, or has a very high cost of learning. In the end, the project was completed in Python, using streamlit and altair as the dynamic interaction and visualisation tools. These two tools are less technical and support a rich set of representations, which makes them very useful.

The specific dataset used was also very different from the original idea. I referenced My Carbon Footprint [4] and used data sources for food [5], electricity [6], and other emissions [7], all from trusted organisations. Data on global temperatures were obtained from NOAA National Centers for Environmental information [8].

It is worth noting that using carbon emissions to estimate the impact on future temperatures is probably the trickiest part of the project. This part of the data involves a lot of formulae, details of which can be found in [9].

Discussion

To show the importance of the climate change issue through data visualisation, time is an element that cannot be left out. How past events have accumulated to become the present, and how possible choices in the present will affect the future, are what the viewer should think about when reading the results of the visualisation. However, it is not easy to rationalise the presentation of time as a factor in visualisation means, and there is often a trade-off between narrative validity and expressive power [10]. In Approach 2, the original design goals tended to favour revealing the spatial element of the climate crisis, but the temporal element deserves to be considered as well, and the narrative patterns it involves can be applied to the overall programme design as well. In conventional timeline design theory, visual representation, scope and layout are considered as three perspectives, which can also be applied to the design of this project. For example, the spiral representation shows how small changes gradually expand exponentially and radially over time and space, and the multiple timeline layout shows how different choices and strategies will gradually create specific impacts, achieving an obvious contrast. As for Scale, the multiple strategies all seem to have different strengths: Logarithmic strategies are suited to longer and unevenly distributed stories, which is perfectly in line with the characterisation of climate change [10], whereas Sequential + Interim Duration allows for a mix of sequential and temporal combinations, with plenty of opportunities to add additional narration to highlight key events [10]. events to emphasise them [10]. Our final choice is Sequential, which is more in line with natural human logic and more intuitively reflects future changes.

Future Work

In future work, we hope to provide better usability of the product, including: 1. more options.

1. More options. Provide users with better estimates without increasing their cost of ownership.
2. more future. In addition to temperature change, there are many important issues related to carbon emissions.
3. Deployment as SaaS. This will allow users from all over the world to experience the project, thus truly connecting humanity.

Conclusion

In this work, we have implemented a web-based visualisation platform that interactively visualises users' carbon emissions data and shows its long-term impact on the world based on data. This project is dedicated to addressing climate change and achieving a sustainable future.

Reference

[1] WWF Footprint Calculator, https://footprint.wwf.org.uk/questionnaire

[2] Myclimate calculator, https://co2.myclimate.org/en/footprint_calculators/new

[3] United Nations Carbon offset platform, https://offset.climateneutralnow.org/footprintcalc

[4] My Carbon Footprint, https://www.carbonclick.com/personal-footprint-calculator

[5] Hannah Ritchie, Pablo Rosado and Max Roser (2022) - "Environmental Impacts of Food Production". Published online at OurWorldInData.org. Retrieved from: 'https://ourworldindata.org/environmental-impacts-of-food' [Online Resource]

[6] Country Specific Electricity Grid Greenhouse Gas Emission Factors, https://www.carbonfootprint.com/docs/2020_07_emissions_factors_sources_for_2020_electricity_v1_3.pdf

[7] Greenhouse gas emissions by source sector, https://ec.europa.eu/eurostat/databrowser/view/env_air_gge/default/table?lang=en

[8] NOAA National Centers for Environmental information, Climate at a Glance: National Time Series, published December 2023, retrieved on December 17, 2023 from https://www.ncei.noaa.gov/access/monitoring/climate-at-a-glance/national/time-series

[9] How are CO_2 concentrations related to warming? https://factsonclimate.org/infographics/concentration-warming-relationship

[10] Matthew Brehmer, Bongshin Lee, Benjamin Bach, Nathalie Henry Riche, and Tamara Munzner. Timelines Revisited: A Design Space and Considerations for Expressive Storytelling. IEEE TRANSACTIONS ON VISUALIZATION AND COMPUTER GRAPHICS. Vol 23, issue 9, 2017.