PROJECT CLIMATALE

Fernando Arroyo

Jose Bau

Miguel Carrasco

Javier Fernandez

Alexander Holmes

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Abstract

Project ClimaTale is an app designed to enhance awareness about the consequences of CO2 and CH4 in our planet. It is designed for young and not so young people. It is an interactive game where you can learn about the impact and interaction of these greenhouse gases while having a good time playing.

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Introduction

As part of the "Tell Us a Climate Story!" challenge, we have chosen to convey our message through the dynamic means of a video game. Among the many storytelling formats, a game offers an engaging and interactive way to reach people of all ages. By incorporating real-world climate data into its mechanics, our game not only provides a captivating experience but also serves as an educational tool, allowing players to learn through its gameplay. That's why we've named it *ClimaTale* –to reflect its mission of communicating knowledge about pressing climate issues from across the world in an accessible way.

ClimaTale focuses on illustrating the current relationship between the greenhouse gasses CO2 and methane (CH4) by exploring their levels and impacts on the environment via gameplay and informative cards.

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The Game

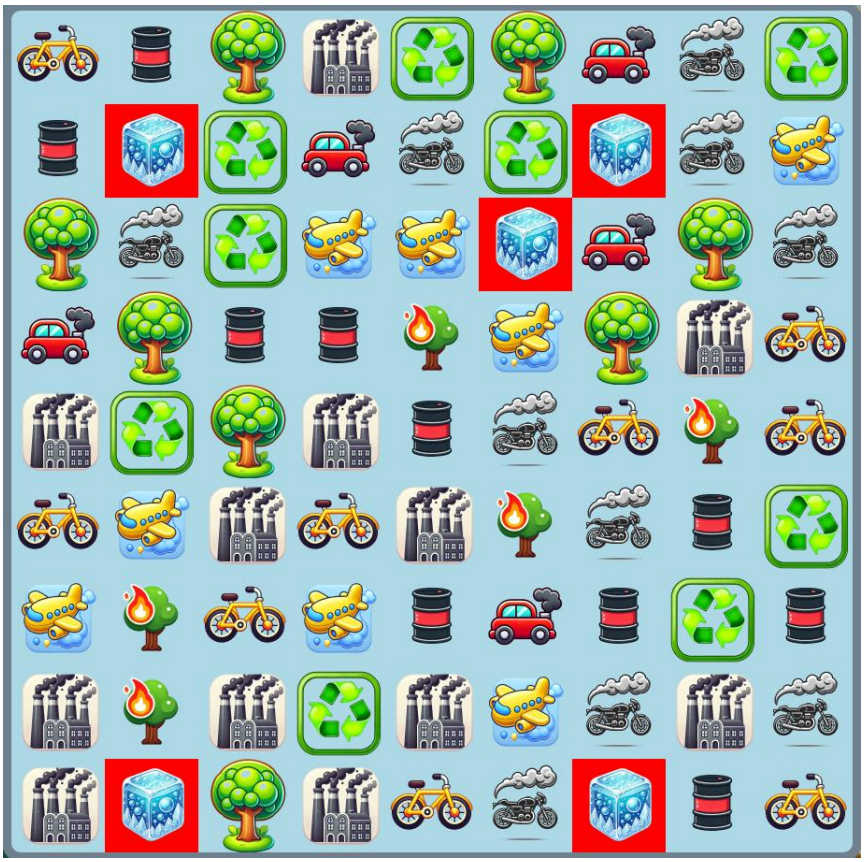

Figure 2.1: *Screenshot from the ClimaTale's MVP demo.*

ClimaTale is a mobile puzzle game where players match three or more objects of the same kind to clear them from the board and earn points.

2.1 Objective

Each level begins with an initial carbon dioxide concentration based on actual measurements from the city that the level represents. The player's goal is to reduce that

concentration to zero by eliminating CO2 producers such as planes, cars, factories and others.

The different levels consist on different countries. At the beginning, the first levels consist of the countries which have less CO2 and CH4 emissions. Then the game advances through all the countries in an increasing order, being the last levels the countries which have the highest levels of CO2 and CH4. The difficulty is ascending.

2.2 Core mechanics

2.2.1 Swapping Objects:

Players swap adjacent objects to create matches. When three or more objects are matched, they disappear, and new objects fall from the top.

2.2.2 Eliminating CO2 producers:

Figure 2.2: *Objects that emits CO2.*

Eliminating elements from the Figure 2.2 reduces the CO2 concentration. The extent of the reduction depends on which objects are removed and how much CO2 they produce.

2.2.3 Eliminating CO2 reducers:

Figure 2.3: *Objects that reduces the CO2 concentration.*

Eliminating elements from the Figure 2.3 increases the CO2 concentration as something beneficial for the environment has been destroyed.

2.2.4 Generating items:

Depending on the type of level, the initial arrangement of elements will vary based on the probability derived from the expected carbon dioxide concentration measured in the city over recent years. Each new row of items falling from the top represents a month (this data is retrieved from Center, 2022). If the CO2 levels in the city are

increasing, each new month—and thus each new row—will be progressively more challenging. Conversely, if the levels of CO2 in the country are decreasing, each new row will be easier than the one before.

In order to achieve this, in each iteration a hyperparameter (λ) depending in the CO2 concentration will be generated, such that if the elements of the Figure 2.2 are in the set $\mathcal{A}$ and the elements of the Figure 2.3 are in the set $\mathcal{B}$. The new generating probabilities are computed as follow:

$$Q_i = \mathcal{P}(a_i) + \lambda \qquad \text{with } a_i \in \mathcal{A} \tag{2.1}$$

$$N_j = \mathcal{P}(b_j) - \lambda \qquad \text{with } b_j \in \mathcal{B} \tag{2.2}$$

in these new values there are some of them that are negative and others that are bigger than one. As the sum of all the probabilities needs to equal one, the values have to be normalized, so the new probabilities are:

$$\mathcal{P}(a_i)' = \frac{Q_i + |\min_{i,j}(Q_i, N_j)|}{\sum_{i,j}[Q_i + N_j + 2|\min_{i,j}(Q_i, N_j)|]} \tag{2.3}$$

$$\mathcal{P}(b_j)' = \frac{N_j + |\min_{i,j}(Q_i, N_j)|}{\sum_{i,j}[Q_i + N_j + 2|\min_{i,j}(Q_i, N_j)|]} \tag{2.4}$$

2.2.5 Frozen CH4:

Figure 2.4: *CH4 frozen if its destroyed, it release CH4 to the atmosphere.*

Frozen CH4 are a special type of blocks marked by its reddish background. They represent the so-called methane calthrate, which are high amounts of methane that are frozen in permafrost Arctic areas. Given that the methane is more than 28 times as potent as CO2 at trapping heat in the atmosphere Agency, 2023, we will introduce this fact in the gameplay. The idea is, once the player destroys the frozen blocks, methane should be released and then, because of that equivalence, the levels of CO2 must arise the corresponding amount of methane.

2.2.6 Burning trees:

Like frozen methane, the burning tree is another special object marked by a reddish background that affects badly on the release of methane. While trees had a positive effect in pollution reduction by trying to keep them in the map, burning trees have the opposite effect. The fire can spread to the adjacent trees and will continue to increase CO2 levels as it is continuously releasing methane into the atmosphere. They

Figure 2.5: *CH4 frozen if its destroyed, it release CH4 to the atmosphere.*

get destroyed every three turns releasing even more amounts of methane. The possible strategy to counter its effects is to finish the level as soon as possible or achieving a layout that doesn't have any trees near burning trees.

2.3 Levels:

Each level has a different layout and objectives. As players progress, levels become more challenging, as the pollution levels are higher and therefore, the levels are generated with a higher probability of being more difficult.

Moreover, there are some type of levels in which the CH4 appears to make things a little bit spicier. These levels are:

2.3.1 Antarctica levels:

In these levels we have some frozen CH4 cubes that if destroyed, the release methane to the atmosphere. As it is said in Agency, 2023, CH4 has a much higher GWP (Global Warming Potential) so its presence in the air is equivalent to a huge presence of CO2. Because of this equivalent this event will boost the amount of CO2 concentration. There could be some special levels in which the temperature of the earth is risen so every three turns a CH4 cube will melt releasing the methane of its interior.

2.3.2 Rural levels:

There are some levels that are set in the countryside, where the agriculture and the livestock are a substantial part of the local economy and ecosystem. In these levels, every two turns the CO2 concentration will increase a little.

2.3.3 Wildfire levels:

These levels start with some trees burning. The possible strategy to counter its effects is to finish the level as soon as possible or to achieve a layout that doesn't have any trees next to the burning trees.

2.3.4 Armageddon levels:

These levels are set in a dystopian future where the global warming has made some places in the earth inhabitable. These cause the appearance of burning trees and frozen

CH4 cubes at the same time. If a burning tree is next to a CH4 cube, the fire will be extinguished but at the cost of releasing the methane into the atmosphere.

2.4 Winning and Progressing:

Completing the level successfully allows players to advance to the next level, while failing may require replaying.

Overall, the game combines strategy, timing, and a bit of luck to clear levels and progress through its colorful, sweet-themed world.

3

Climatale's Vision and Scalability

3.1 Vision

With its colorful, cartoonish aesthetics, the game initially appeals to younger audiences, making it possible to introduce a story that raises awareness about the effects of these gases. However, the incorporation of real-world climate change data broadens its appeal by adding a level of realism that many other mobile games lack.

Each level in ClimaTale represents a progression through different years and cities, with each cleared row advancing time. As the data shows, pollution levels tend to increase over time, and this is reflected in the gameplay. After clearing a row, new objects that appear have a higher chance of contributing to pollution rather than reducing it. This design choice highlights how, as the years go by, it becomes progressively harder to combat climate change, emphasizing the increasing difficulty of reversing its effects.

The main objective of this game is to introduce players to CO2 data and its evolution over time, while highlighting that methane is also a greenhouse gas of significant concern. With its simple gameplay, ClimaTale is designed to be easy to learn, helping players understand the harmful effects of CH4 emissions.

3.1.1 Interface decisions

To keep things as simple as possible, we chose to use a single score bar that represents the effects of both CO2 and CH4. To achieve this, we relied on the Global Warming Potential (GWP) index, which compares the infrared thermal radiation absorbed by a greenhouse gas to the amount that would be absorbed by CO2 over the same period of time.

To keep the interface as streamlined as possible, most data will be hidden during gameplay, prioritizing learning through game mechanics. After each level, a pop-up will appear with interesting facts about climate change and greenhouse gases. Additionally, for those who wish to gain a deeper understanding of what's happening, there will be a screen that provides detailed information on the scientific processes and concepts needed to fully grasp the situation.

3.2 Scalability

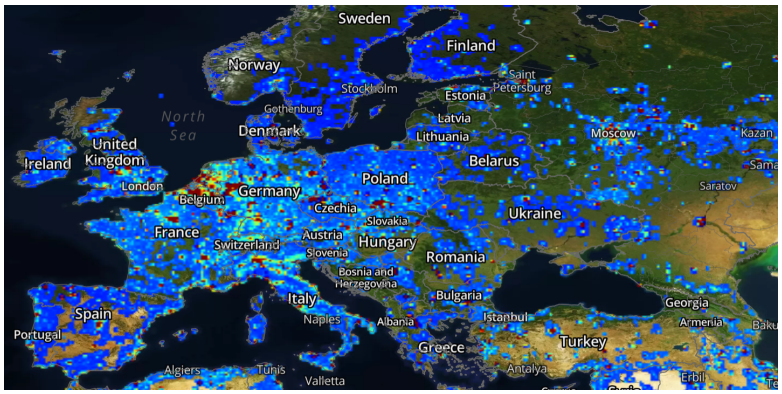

Figure 3.1: *Colormap example of Europe from U.S. Greenhouse Gas Center.*

In its current state of development, the planned number of levels is insufficient to maintain continuity and player engagement, as the game would end too quickly. To address this issue, Artificial Intelligence can be used to dynamically generate additional content.

The U.S. Greenhouse Gas Center provides multiple datasets on fossil fuel CO2 emissions, some of which include interactive colormaps and graphs displaying emission levels across various regions. This real-world data can be integrated into the game to enhance both realism and scalability.

Based on the colormap in the figure 3.1, it's possible to develop an algorithm that, given the name of a city, selects the corresponding region on the map and adjusts the level's difficulty according to the color assigned to that area. The color intensity, which represents the level of emissions, will directly influence the challenge. This will adjust the hyperparameter, increasing the probability of pollution-generating objects appearing compared to others. Explicitly, given the mean value of all the colors along every year, μ, and picking the maximum value, ξ, that hyperparameter would be calculated by $\lambda = \mu/\xi$.

4

Tools

Some external tools were used in the development of this project:

- **Dall-E**. This AI system creates images from given prompts. All object images, backgrounds and the logo were generated via this AI.
- **ChatGPT**. Some paragraphs of the current document were rephrased using this LLM in order to improve the clarity of its presentation.
- **GitHub**. All the game code was picked from the GitHub page ImKennyYip, 2022, and then modified in order to fit our requirements.

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