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Prof. Dr. Peter Crnokrak

Prof. Daniel Bastian

EcoTune: Transforming Carbon Footprint into Music to Evoke Emotional Resonance

Aswathy Sudhakaran

Matriculation no: 25135404

aswathy.sudhakaran@ue-germany.de

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University of Applied Sciences Europe
Iserlohn · Berlin · Hamburg

EIGENSTÄNDIGKEITSERKLÄRUNG / STATEMENT OF AUTHORSHIP

Aswathy
Name | Family Name

Sudhakaran
Vorname | First Name

25135404
Matrikelnummer | Student ID Number

Transforming Carbon Footprint into Music To Evoke Emotional Resonanc
Titel der Examsarbeit | Title of Thesis

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Abstract

This project is aimed to resolve people's emotional disconnect towards the concept of climate crisis. Secondary research was done on the impact of music on emotions, and how it can be used to tackle climate crisis. Using the findings from the research, a mobile application was ideated and designed to help people track and calculate their carbon footprint. The user's monthly carbon footprint is generated for the user as a 30 second musical compositions using data sonification technology. For the purpose of the project prototype, a data sonification platform 'TwoTone' by Sonify was used where the data can be uploaded and specific instruments can be assigned to each metrics of the contributors of carbon footprint, ie., Household energy consumption, Transportation, Food consumption and Shopping/Activities. The settings of the instruments can be adjusted. The frequency of instrument track tempo increases as the user's carbon footprint increases in value per month. This creates a sense of urgency and danger as the music can become quiet disturbing as the track tempo increases. This makes the user aware of their carbon contribution on an emotional level. The app also offers the user ways in which they can reduce or offset their carbon emission and also to track their progress in it. The project prototype was successfully developed, and the concept outcome and usability of the app is yet to be studied.

Section 1: Introduction

Motivation

With technology developing rapidly over the years, the rate of climate change has also been increasing rapidly. Even at the face of such a huge global environmental issue, the hunger for technology companies to innovate with disregard to the climate crisis is unsettling. However, on the other hand, there has been developments in ways to tackle climate crisis. Even though the issue regarding climate crisis has started years ago, the general public still fail to understand the urgency of catering to a solution. The majority of the world conveniently turns a blind eye towards the issue claiming that there's nothing they can do. It has been increasingly difficult to make people make mindful choices in such a happening and fast-paced technological era. Emotions play a crucial role in an individual's behaviour as they direct attention, mould thoughts, and generate impulses and motives to take action (Kovács et al., 2023). An approach where awareness about climate crisis is created on individual levels and evoking an emotional reaction is taken in order to encourage people to take action.

Concept

This project aims to design a mobile based application that calculates an individual's carbon footprint based on their household energy consumption, travel, dietary habits and shopping habits on a daily basis. The monthly and yearly results are made into musical compositions using data sonification. A musical approach is taken here based on the findings that music has the ability to evoke an emotional connection between the listener and the subject. This has the potential to sensitize the user to climate crisis more effectively due to the emotional impact that it creates, and actions are often driven by emotions. After extensive research on the co-relation between emotion, music and climate crisis, this project was ideated and developed. This application is focused solely for the use of individual users and not for companies, organizations, or countries.

The input data is collected automatically or in a less tedious and convenient way so that the user does not have to put much effort or time in order to input data every day. From a usability study done on a carbon footprint app, the users found the data input to be the most frustrating task as they had to remember data or collect bills to input several data (Bekaroo et al., 2019). These results were also taken into consideration while designing this app.

Target Users

Working professionals in the age group 21-50 was chosen as they have comparatively more carbon footprint due to work related mobility.

The app is designed specifically for the use and benefit of individuals and not companies/organizations.

Relevance of Study

The issues regarding climate change have received significant attention since the 20th century, however, the majority of the population has failed to make conscious decisions to minimize the problem. The most effective way to tackle the climate crisis is to create awareness about the urgency of the situation and encourage each individual to make environment-friendly choices and make significant changes in their lifestyle. Many factors such as environmental stability, human well-being, economic stability, social equity, resource conservation, and cultural preservation are dependent on the stability of the ecology.

Music has a powerful impact on emotions due to its ability to resonate specific feelings and moods. Using music in an experiential design to inspire a sense of urgency about the climate crisis on a personal level can trigger people to act consciously more often. This can foster a deeper connection to the issue, motivating individuals to make sustainable choices.

Problem Statement and Research Question

Problem Statement

Despite the existence of carbon footprint calculators, these platforms fail in utilizing the carbon footprint data of individuals to motivate them to take action to reduce carbon footprint. There is a disconnect between climate crisis and people's emotional response to it.

Research Question

How can we encourage individuals to reduce their carbon impact by evoking an emotional reaction to climate crisis?

Project Structure and Research Methodology

The structure of the MA thesis paper is oriented towards the research, design and prototype development of a product, in this case, a mobile application. This paper consists of four main sections; section 1 consists of a general description, motivation and

relevance where a theoretical base is laid. Section 2 consists of insights gained from a thorough secondary research on relevant topics. Section 3 contains comparative analysis, in-depth details of the design project, the tasks carried out for the development of the prototype and the outcome of the design. Section 4 consists of the conclusion and outlook of the project.

Section 2: Background Research

Influence of Art and Design in Climate Crisis Awareness

It is often such that the discussion around climate change and climate crisis can seem like an abstract concept and fails to create empathy or an emotional reaction, or even when it does, it rarely lasts long enough to encourage someone to make a contribution to climate crisis in any form (Sabra and Al-Moaz, 2022). Art and design have been successful in bridging the gap between a social/environmental/political issue and an individual since many centuries in different forms and mediums. Many musicians have contributed largely to the issue of climate crisis by engaging their audience through their music to talk about climate crisis since decades. '*A Day In The Life Of a Tree* – 1971' by The Beach Boys, the charity single music video '*Earth* - 2019' by American rapper and comedian, Lil Dicky, '*The Warnings part 1 and 2* - 1970' by David Axelrod are some of the examples where musicians have attempted to create awareness about climate crisis in their own artistic ways to influence the audience's emotions through music.

Functional design for the ecosystem and human survival has slowly started to become an integral part of design culture. Design has the ability to holistically shift how something is perceived by human beings and can influence human emotions and mindset. By transforming the design thinking practices for a human-centered design to encompass both the environment as well as human beings, designers have the power to shift the paradigm of what a design can do. Data sonification is a type of generative music based on real-time data. Studies about the use of data sonification for the purpose of communicating environmental data has been explored and experimented. This project aims to make this concept fruitful to everyone through a medium that is accessible to everyone, that is, through their personal computers or mobile phones. The idea is for it to be available to the users where they can track and generate their own carbon footprint results.

Calculation of Individual Carbon Footprint

Carbon footprint is the total amount of greenhouse gases produced by the actions of an individual/organization or country. Major contributors of greenhouse gases are: *Carbon dioxide, Methane and Nitrous oxide*. It is measured in carbon dioxide equivalent (unit of measurement is kilogram/kiloton).

One ton of methane is equivalent to 21 tons of carbon dioxide.

One ton of nitrous oxide is equivalent to 310 tons of carbon dioxide.

Direct/Primary footprint is carbon emission from domestic energy consumption and transportation.

Indirect/Secondary footprint comprises of emissions from lifestyle choices (shopping, diet) and services.

Carbon footprint calculations help individuals make sense of their carbon contributions based on their activities and also shows which metric contributes most or least to impact their total carbon footprint score. This method can quantify an individual's carbon impact and promote increased awareness, knowledge and mindfulness when making lifestyle choices.

Evaluation of People's Response to Climate Change

Several studies have established that stronger negative emotions to the climate crisis are associated with more pro-environmental behaviour and such individuals were more likely to take action to mitigate climate change (Kovács et al., 2023).

Taking steps to tackle climate crisis on an individual level demands sacrifices, significant lifestyle changes and has economic consequences as sustainable choices often comes with a higher price tag for which people might be unwilling to adapt to. Based on the analysis done on the data collected from the people of Ecuador, a country where many implementations were made for the mitigation of climate crisis on an individual level, the participants reported 'Concern,' 'guilt,' 'powerlessness,' 'anger,' and 'confusion' as the emotions they have felt most (Iniguez-Gallardo et al., 2021).

Based on the study conducted by Jack et., al (2023) by calculating carbon footprint of participants and interviewing them about their reaction to their footprint score, it was revealed that participants with lower score reflected on their actions and were willing to reduce their carbon emission in the future whereas those with higher score where dismissive of their score and expressed that individual effort is pointless (Jack, et al., 2023).

There is a potential for reducing the total carbon footprint by using a carbon footprint calculator application. Based on the user's financial transactions (bank connected to app) and data input by users, the app provides total footprint, footprint of individual category and individual purchases. The app also provides suggestion on how to reduce carbon impact and social comparison with groups. The detailed results across all categories provide a chance for the users to reflect and pinpoint areas of improvement and was able to reduce 11% emissions after app installation but the results were temporary. This study demonstrates the potential of pro-environmental users to reduce carbon their footprint, but they lack motivation to be consistent (Enlund et al., 2023)

Leveraging The Effect of Music on Emotions to Tackle Climate Crisis

There is a rich history of the role of music in influencing people's thoughts, forming connections, inspiring action, forming individual and collective identities, regulating moods and expressing people's beliefs and values. Something as powerful as music can be leveraged to solves the problem associated with climate change (Prior, 2022).

"Visual aids have limitations: they are most easily understood by people who are fluent in technical illustrations; they are usually static and sometimes do not tell an obvious story; and many people do not respond to them emotionally. Music, by contrast, builds each note or phrase upon those that came before, and can exert a powerful influence on human emotions. Because of these characteristics, *sonification*—the transformation of data into acoustic signals—may have considerable promise as a tool to enhance the communication of climate science" (St George et al., 2017, p.23).

Related Projects: Data Sonification for Climate Crisis

Data was taken from the first UK Earth System Model and converted into six musical pieces that covered the core principles of climate modelling. By limiting to a single instrument (piano), a range of musical styles were created (De Mora, et al., 2020).

A research project called SySon developed a method for data sonification using climate data. SySon reported certain obstacles when introducing sonification in a scientific domain. There was a cultural bias as using sound in a scientific setting was not traditionally done. There were also questions about quality control, usability and technical barriers like compatibility of data with audio softwares (Groß-Vogt and Goudarzi, 2013).

A sonification process was created by George and his team to convert climate time data into a set of musical notes and these compositions were published online along with a short written description and video outline. It gained popularity and many viewers commented that they were surprised to by the use of music to communicate climate change and that the experience was memorable even though the composition was unsettling or unpleasant (St George et al., 2017).

Treelab by Marcus Maeder and Roman Zweifel

Treelab is an artistic-scientific research project that records acoustic emissions and other physiological data from trees in the Swiss Alps using special sensors and data sonification is used to convert these acoustic data into sounds and music. This project aims to observe the condition of trees and how climate change has had an impact on them. Moreover, it is an artistic expression and an

auditory experience of how climate change has put pressure on the environmental condition of trees. This project is motivated by several climatic changes like decline in biodiversity, deforestation, ocean acidification among other changes brought on by the Anthropocene era.

“Our auditory senses have always played an important role,” says Marcus Maeder, an environmental scientist, sound artist and practitioner in the field of data sonification. “We have the capability to analyse what we hear very quickly. This had evolutionary benefits because we could quickly identify sound sources and their position. It enabled us to survive ‘the tiger waiting in front of our cave’. But sound also seems to connect more directly to our emotions. Maybe because of music’s history as an emotional form of communication. It begins with your mother singing for you and perhaps ends with a pop song touching you when you hear it on the radio.” (Maeder, 2023, Sound the Alarm: Data Sonification as a Tool for Climate Action, n.d.).

Sonify: TwoTone – A Data Sonification Platform by Hugh and Debra McGrory

TwoTone developed by Sonify is a free online platform that converts data into sound without the use of any code. It is created with support from Google News Initiative. Sonify aims to create deeper connections through audio to increase impact, interaction and reach among the userbase. Rather than replacing data visualization, the goal is to complement visualization with sonification.

WWF Footprint Calculator

WWF (World Wildlife Fund) is a global conservative organisation that aims to protect people and nature. It is active in around 100 countries and has several programs and collaborations to protect communities, wildlife and their habitats.

WWF UK has a platform as well as a mobile app that helps you track, calculate and reduce your carbon footprint. This platform is specifically for the use of people in the UK.

Carbon Footprint Tracker Mobile App by The Capture Club

It is a free mobile app that helps the user understand about their impact on environment from their everyday commute, food consumption choices, lifestyle etc. The data about the user’s transportation will be automatically tracked using the phone’s GPS facility. The app’s target audience is individuals and companies.

The app could have added the facility to track travel without the user having to enter the data manually. Even with the location tracking feature, the data is not recorded accurately.

The data concerning the user's home energy consumption or shopping habits are not considered when calculating the carbon footprint.

PawPrint Mobile App

PawPrint is a mobile app that helps you measure and reduce your carbon impact with interactive gamification features. It targets individual users as well as companies. It acts as a corporate climate action platform that enables team engagement to take action against carbon emission, empower employees and set sustainability goals in a fun and challenging way.

The app has a very clear and well-structured user experience that takes the user through a satisfying journey and a sense of achievement and goal completion.

Section 3: Design Development

Comparative Analysis

The five products discussed in section 2 are chosen for comparative analysis based on the topic categories, ‘data sonification of climate change’ and ‘carbon footprint calculator’. The proposed product closely aligns with these 2 categories.

Table 1

Comparative Analysis of Competitors

Product → / Features →	Treelab Project	Sonify: TwoTone	WWF UK Footprint Calculator App	Capture App (Carbon Footprint Tracker)	PawPrint App	Ideal Features	
Real-time tracking	Real-time tracking of drought stress in trees by installing acoustic sensors under tree barks.	N/A	Track the progress of the user’s impact	Real-time tracking of user’s transportation (from device location) and dietary habits (manual input). Track the progress of user’s impact	Track the progress of the user’s impact	Track the progress of the user’s impact	Real-time tracking of user’s transportation (from device location) and dietary habits (manual input). **Track the progress of user’s impact**
Impact comprehension (visualization/sonification)	Data sonification for environmental communication	Data sonification platform	Using visualization tools: Donut chart and percentage breakdown of the metrics contributi	Progress ring to visualize progress of impact reduction. Progress bar to visualize total emission	Data visualization using paw design with overall emission per year, 4	Data sonification for environmental communication	Data sonification platform

			ng to CO2 emission calculation	and emission caused by transportation and food	contributor metrics and one metric that shows change in impact. Additionally, progress bars to display 3 of the same metrics		
Integration with carbon offsetting projects	None	N/A	Several projects that include adoption of animals, donation, challenge events, gifting, philanthropy etc	Integrations with carbon offsetting projects for payment contribution is done in monetary form	Integrations with carbon offsetting projects where the contribution is done through PawPoints made from completing tasks and maintaining habits	Integrations with carbon offsetting projects where the contribution is done through PawPoints made from completing tasks	
Goal setting and gamification	N/A	N/A	Available	Available	Available Clear and well-structure	Goal setting and gamification available Clear and well-structured goal setting experience	

					d goal setting experience	
Community sharing/group engagement	Public showcase at unexpected location to the audience who are not already sensitive to climate change	**Export and share music compositions made from the user's database**	Share carbon emission score.	Join or invite your work community to contribute to ecological wellbeing.	Join or invite your work community to contribute to ecological wellbeing.	Export and share music compositions made from the user's database
Accessibility & open data	Scientific research project material available to study.	Code free, user friendly open-source web-based platform. Export and access your own data for analysis or integration with other platforms	User friendly mobile app available for everyone in the UK	User friendly mobile app available for everyone	User friendly mobile app available for everyone	Code-free, user friendly open-source web-based platform. Export and access your own data for analysis or integration with other platforms

User Personas and Their Carbon Footprint Data

User 1

Eco-Conscious Champion

Name: Ryan

Age: 40

Occupation: Environmental Activist

Ryan has a strong belief in living sustainably. He has devoted his life to supporting environmental causes and has made deliberate decisions to keep his carbon footprint small. Ryan is aware of environmentally friendly behaviours and actively looks for methods to reduce his impact on the environment. In order to lessen his carbon impact even more, he is searching for an app that offers challenges and sophisticated insights.

Goals:

- Preserve and minimize an already minimal carbon impact.
- To improve sustainable practices, get access to cutting-edge analytics and insights.
- Share her success in leading a sustainable life.
- Encourage people to live sustainably and inspire them.

Table 2

Carbon Footprint Data of User 1: Ryan

Date	Household Energy Consumption (in kg CO_2)	Transportation (in kg CO_2)	Food Consumption (in kg CO_2)	Shopping/Other Activities (in kg CO_2)	Carbon Footprint per day (in kg CO2)
01-11-2023	0.21	1.16	3.81	0	5.18
02-11-2023	0.45	0	2.89	0.45	3.79
03-11-2023	0.41	1.16	2.89	1.12	5.58
04-11-2023	0.53	0	0	0.32	0.85
05-11-2023	0	2.21	3.81	0	6.02
06-11-2023	0.42	3.21	2.89	6.34	12.86
07-11-2023	0.23	0	3.81	0	4.04
08-11-2023	0.23	1.54	2.87	3.54	8.18
09-11-2023	0	0.54	2.89	1.65	5.08
10-11-2023	0.54	0	1.98	0.32	2.84
11-11-2023	0.48	0.65	2.89	0	4.02
12-11-2023	0.27	1.84	3.81	0.42	6.34
13-11-2023	0.15	0.32	0	9.34	9.81
14-11-2023	0.26	0	2.21	0	2.47
15-11-2023	0	0.43	3.81	0.91	5.15
16-11-2023	0.45	1.56	2.89	1.56	6.46
17-11-2023	0.49	0	2.01	0.21	2.71
18-11-2023	0.47	2.09	0.87	0	3.43
19-11-2023	0.68	1.93	1.24	10.45	14.3
20-11-2023	0.24	0.54	0	0	0.78
21-11-2023	0	0	3.81	0.25	4.06
22-11-2023	0.56	1.47	2.89	4.01	8.93
23-11-2023	0.24	0	3.89	0	4.13
24-11-2023	0.31	1.93	3.21	0.44	5.89
25-11-2023	0.36	2.78	2.89	8.9	14.93
26-11-2023	0.13	0	3.81	0	3.94
27-11-2023	0.19	0.56	3.54	0.78	5.07
28-11-2023	0	0	3.81	0.22	4.03
29-11-2023	0.55	2.76	0	1.65	4.96
30-11-2023	0.43	0.67	2.89	0	3.99
Carbon Footprint per Category	9.28	29.35	78.31	52.88	169.82

User 2

Average Joe

Name: Gina

Age: 28

Occupation: Office Manager

Gina has an average carbon footprint and lives a normal urban lifestyle. Despite her concern for the environment, it's possible that she is unaware of how much everyday activities contribute to carbon emissions. Gina is looking for an app that offers clear, doable instructions for progressively lowering carbon footprint without unduly interfering with daily activities.

Goals:

- Find and reduce her own carbon footprint with minimal lifestyle changes.
- Obtain recommendations that are unambiguous and direct.
- Follow development in an understandable manner.
- For inspiration, provide creative solutions.

Table 3

Carbon Footprint Data of User 2: Gina

Date	Household Energy Consumption (in kg CO_2)	Transportation (in kg CO_2)	Food Consumption (in kg CO_2)	Shopping/Other Activities (in kg CO_2)	Carbon Footprint per day (in kg CO_2)
01-11-2023	0.14	10.19	5.63	2.45	18.41
02-11-2023	0.11	2.83	3.81	1.1	7.85
03-11-2023	0.43	1.16	7.19	0	8.78
04-11-2023	0.45	0	4.67	20.23	25.35
05-11-2023	0.42	0	2.89	0	3.31
06-11-2023	0.34	5.34	3.91	2.23	11.82
07-11-2023	0.98	1.43	2.89	3.45	8.75
08-11-2023	0.56	0	3.91	0	4.47
09-11-2023	0.53	20.38	2.89	9.8	33.6
10-11-2023	0	2.18	2.89	1.12	6.19
11-11-2023	0.67	4.32	7.19	0	12.18
12-11-2023	0.11	1.2	3.91	1	6.22
13-11-2023	0.23	8.21	2.89	6.67	18
14-11-2023	0	2.21	7.19	0	9.4
15-11-2023	0.45	0	2.89	7.32	10.66
16-11-2023	1.45	0.34	3.91	0	5.7
17-11-2023	0.32	0.56	2.89	10.54	14.31
18-11-2023	1.45	0.56	7.19	0	9.2
19-11-2023	0	1.23	2.89	9.23	13.35
20-11-2023	1.89	0.13	3.81	2.23	8.06
21-11-2023	0.34	0.34	2.89	0	3.57
22-11-2023	0.45	15.43	5.63	1.12	22.63
23-11-2023	0.32	1.12	3.81	0	5.25
24-11-2023	0	0	3.91	1.89	5.8
25-11-2023	1.45	2.3	5.63	2.91	12.29
26-11-2023	1.24	3.23	2.89	0	7.36
27-11-2023	0.34	5.67	3.81	1.3	11.12
28-11-2023	1.98	1.12	3.91	1.73	8.74
29-11-2023	1.57	2.23	2.89	0	6.69
30-11-2023	0.52	0	5.63	3.1	9.25
Carbon Footprint per Category	18.74	93.71	126.44	89.42	328.31

User 3

Busy Millionaire

Name: Alex

Age: 45

Occupation: Tech Entrepreneur

As a prosperous tech entrepreneur, Alex lives a fast-paced existence. Alex is conscious of the environmental impact of his high carbon footprint from frequent travel and a busy schedule, but he finds it difficult to make significant changes. Alex requires an app that can fit with his busy schedule and provide offset options and useful answers.

Goals:

- Reduce his carbon footprint in an easy and effective way.
- Get personalized advice on how to lessen his influence on the environment.
- Be able to easily monitor and control activities that impact the environment.
- Using the app, participate in and support environmental projects.

Table 4

Carbon Footprint Data of User 3: Alex

Date	Household Energy Consumption (in kg CO_2)	Transportation (in kg CO_2)	Food Consumption (in kg CO_2)	Shopping/Other Activities (in kg CO_2)	Carbon Footprint per day (in kg CO_2)
01-11-2023	213	1123	3.91	147	1486.91
02-11-2023	432	16800	7.19	217	17456.19
03-11-2023	123	1100	5.63	722	1960.63
04-11-2023	246	16850	4.67	661	17761.67
05-11-2023	113	7830	3.81	936	8882.81
06-11-2023	222	8000	3.91	97	8322.91
07-11-2023	111	8903	5.63	290	9309.63
08-11-2023	123	1270	7.19	197	1597.19
09-11-2023	104	9000	3.81	172	9279.81
10-11-2023	112	78.53	4.67	250	445.2
11-11-2023	120	5102	7.19	726	5955.19
12-11-2023	109	4580	5.63	27	4721.63
13-11-2023	211	8000	3.81	997	9211.81
14-11-2023	121	16000	3.91	927	17051.91
15-11-2023	245	1571.2	7.19	732	2555.39
16-11-2023	356	4153.2	5.63	782	5296.83
17-11-2023	89	16000	4.67	902	16995.67
18-11-2023	90	1270	5.63	682	2047.63
19-11-2023	156	8000	4.67	597	8757.67
20-11-2023	102	257.65	3.81	902	1265.46
21-11-2023	543	1661.28	3.91	780	2988.19
22-11-2023	211	1700	5.63	889	2805.63
23-11-2023	91	5000	3.81	902	5996.81
24-11-2023	103	1661.28	3.81	792	2560.09
25-11-2023	87	7120	3.91	792	8002.91
26-11-2023	311	1000	4.67	203	1518.67
27-11-2023	101	2890	7.19	634	3632.19
28-11-2023	142	802.98	3.91	111	1059.89
29-11-2023	120	2901	3.91	4533	7557.91
30-11-2023	198	802.98	3.91	692	1696.89
Carbon Footprint per Category	5305	161428.1	147.22	21291	188171.32

Data Source

There are 4 types of input data required from the user/user device. They are:

Household energy consumption: This data is acquired by the app automatically after the user enables access to payment history of banking app/payment app.

Transportation: This data is tracked by the app from the GPS location on the phone. It tracks the distance as well as the vehicle travelled in.

Food consumption: This data is directly input by user from the notification panel. If the user fails to input data, the app will input the default option given by the user while answering the baseline questionnaire.

Shopping/Activities: The shopping and activities involving monetary transactions will be automatically tracked by the app from payment history of bank app/payment apps. Other activities need to be entered in by the user.

Data Sonification Method

These data is processed and converted to musical compositions using data sonification. Each 4 types of data input received is assigned with an instrument as follows:

Household energy consumption: Mandolin

Transportation: Double bass

Food consumption: Violin

Shopping/Activities: Electric guitar

The tempo of each instrument in one second is based on the total amount of CO_2e produced per month in each category. The tempo ranges from 1x to 12x. The frequency of the track tempo per second represents the increase in carbon footprint on that specific category.

Table 5

Track Tempo for the Range of Carbon Footprint Emitted

1x	<40 kg CO_2e
2x	<80 kg CO_2e
3x	>80 kg CO_2e
4x	>160 kg CO_2e
6x	>960 kg CO_2e
8x	>1920 kg CO_2e
9x	>5760 kg CO_2e
12x	>23,040 kg CO_2e

For the purpose of the prototype of this project, the data sonification was done using the platform ‘TwoTone’ by Sonify. The user’s daily carbon emission data for a month is prepared to upload in .xlsx file format to TwoTone for sonification as given below:

Table 6

Carbon Footprint Data of User 2: Gina Used for Uploading on TwoTone: Sonify

Date	Household Energy Consumption (in kg CO_2)	Transportation (in kg CO_2)	Food Consumption (in kg CO_2)	Shopping/ Activities (in kg CO_2)
01-11-2023	0.14	10.19	5.63	2.45
02-11-2023	0.11	2.83	3.81	1.1
03-11-2023	0.43	1.16	7.19	0
04-11-2023	0.45	0	4.67	20.23
05-11-2023	0.42	0	2.89	0
06-11-2023	0.34	5.34	3.91	2.23
07-11-2023	0.98	1.43	2.89	3.45
08-11-2023	0.56	0	3.91	0
09-11-2023	0.53	20.38	2.89	9.8
10-11-2023	0	2.18	2.89	1.12
11-11-2023	0.67	4.32	7.19	0
12-11-2023	0.11	1.2	3.91	1
13-11-2023	0.23	8.21	2.89	6.67
14-11-2023	0	2.21	7.19	0
15-11-2023	0.45	0	2.89	7.32
16-11-2023	1.45	0.34	3.91	0
17-11-2023	0.32	0.56	2.89	10.54
18-11-2023	1.45	0.56	7.19	0
19-11-2023	0	1.23	2.89	9.23
20-11-2023	1.89	0.13	3.81	2.23
21-11-2023	0.34	0.34	2.89	0

22-11-2023	0.45	15.43	5.63	1.12
23-11-2023	0.32	1.12	3.81	0
24-11-2023	0	0	3.91	1.89
25-11-2023	1.45	2.3	5.63	2.91
26-11-2023	1.24	3.23	2.89	0
27-11-2023	0.34	5.67	3.81	1.3
28-11-2023	1.98	1.12	3.91	1.73
29-11-2023	1.57	2.23	2.89	0
30-11-2023	0.52	0	5.63	3.1

Figure 1

TwoTone: Sonify Platform Interface

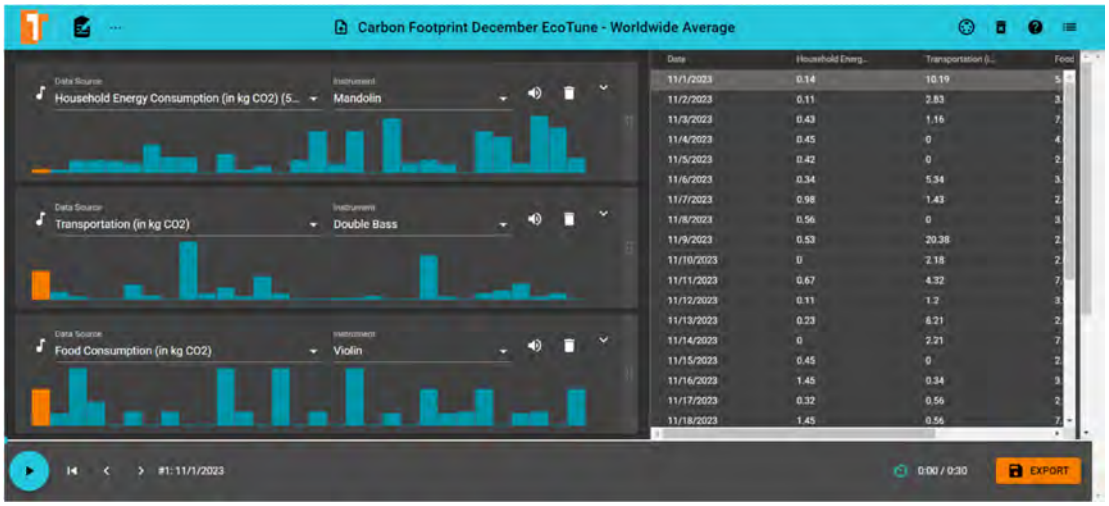
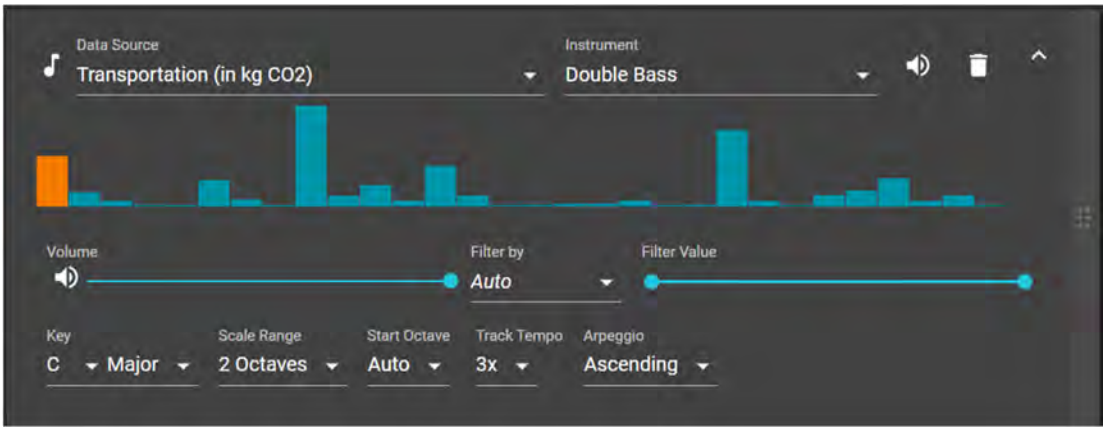


Figure 2

Track tempo marked on TwoTone: Sonify Interface



Here, the track tempo of Double bass: Transportation is changed to 3x as the monthly total value of CO2e of the user is 93.71 kg (as shown in Table 6) and the assigned value of CO_2e greated than 80 kg is 3x (as shown in Table 5).

A musical track with the duration of 30 seconds (1 second for one month) is generated by TwoTone and this audio is used for the app prototype.

Features Of the Mobile Application: EcoTune

Feature 1: Basic Carbon Data Input

Baseline questionnaire where the user inputs data regarding their household energy consumption, travel, diet and shopping/activities.

Figure 3

Figma Screen: Profile

Figure 4

Figma Screen: Travel Mode

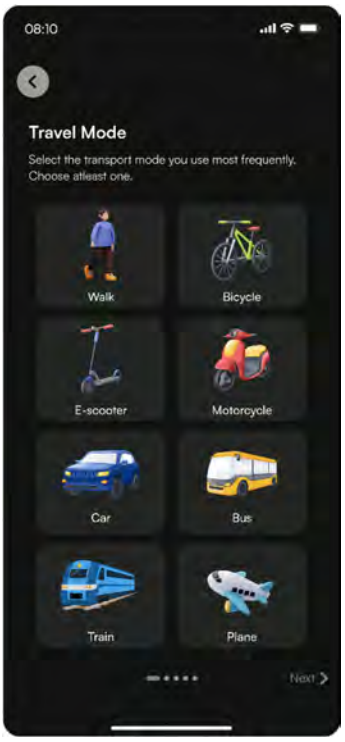


Figure 5

Figma Screen: Travel Time

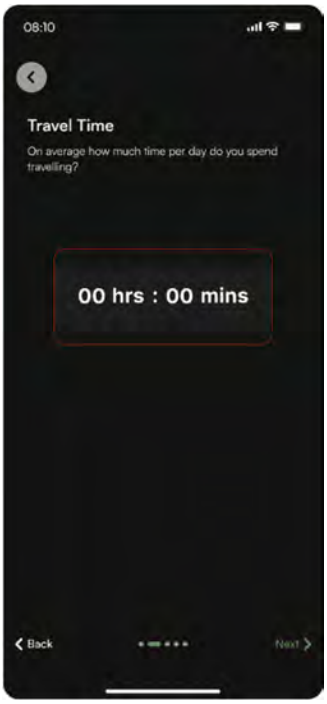


Figure 6

Figma Screen: Your Flights

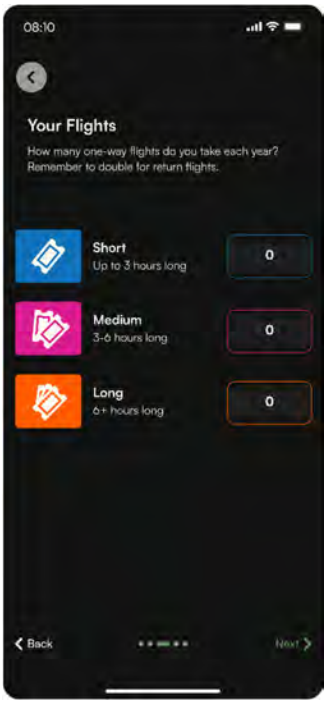


Figure 7

Figma Screen: Your Home

Figure 8

Figma Screen: Diet

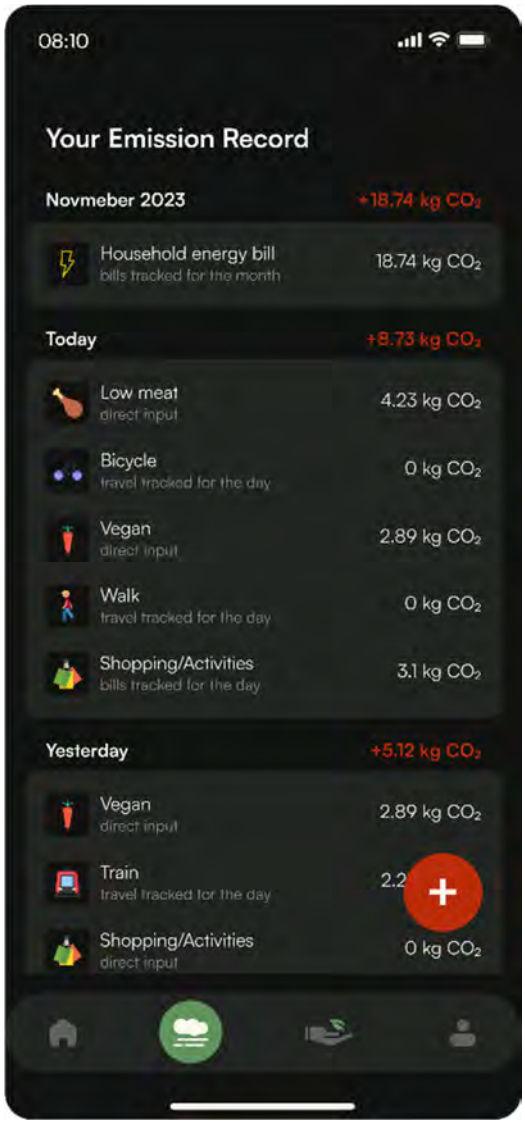
Feature 2: Auto tracking of carbon footprint

Access to google map to track location in order to retrieve data regarding travel mode and distance.

Access to transaction history of bank apps/payment apps, supermarket customer apps (Kaufland, Rewe, Lidl etc) to retrieve shopping bills that contain item/service purchased and amount spent which can determine if the item/service bought are sustainable choices.

Figure 9

Figma Screen: Your Emission Record



Feature 3: Notification Panel Access for Input

Option to input daily food consumption from notification panel to improve easy access and to remind the user every day while also improving the accuracy of carbon footprint calculation.

Figure 10

Figma Screen: Lock screen Notification 1

Figure 11

Figma Screen: Lock screen Notification 2

Feature 4: Home screen

The carbon footprint music (EcoTune) of the previous month is generated on the first day of the coming month. Until then, the EcoTune of the month before that is displayed on the home screen. The user can play the 28-31 seconds track to be able to hear the level of impact of their carbon footprint.

Figure 12

Figma Screen: Home Screen – Data Sonification and Visualization

Based on the results, the user can choose to reduce the impact. The app provides different ways in which the user can reduce/offset their carbon footprint.

Feature 5: Carbon Offset Actions and Habits

Carbon Footprint Reduction/ Offset Action and Habits: User can track the progress of their impact reduction and even form habits out of certain tasks that the user finds doable or beneficial or simply finds interest in doing.

Figure 13

Figma Screen: Your Offset Action and Habits - Actions

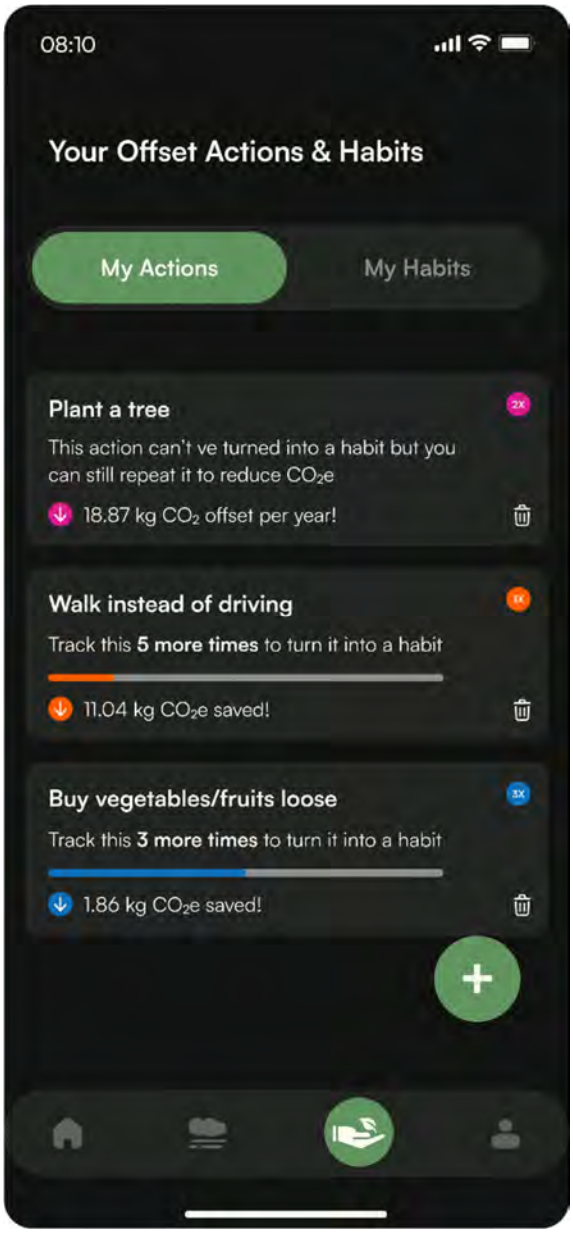


Figure 14

Figma Screen: My Habits

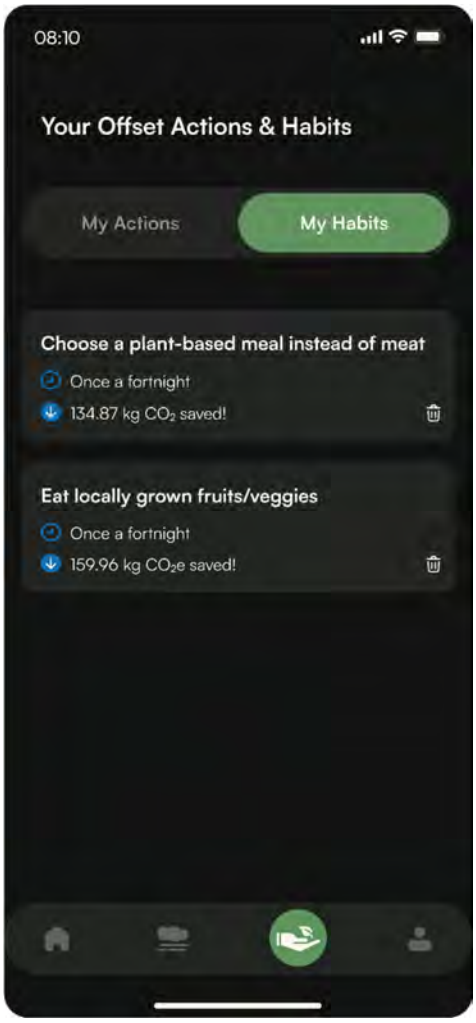
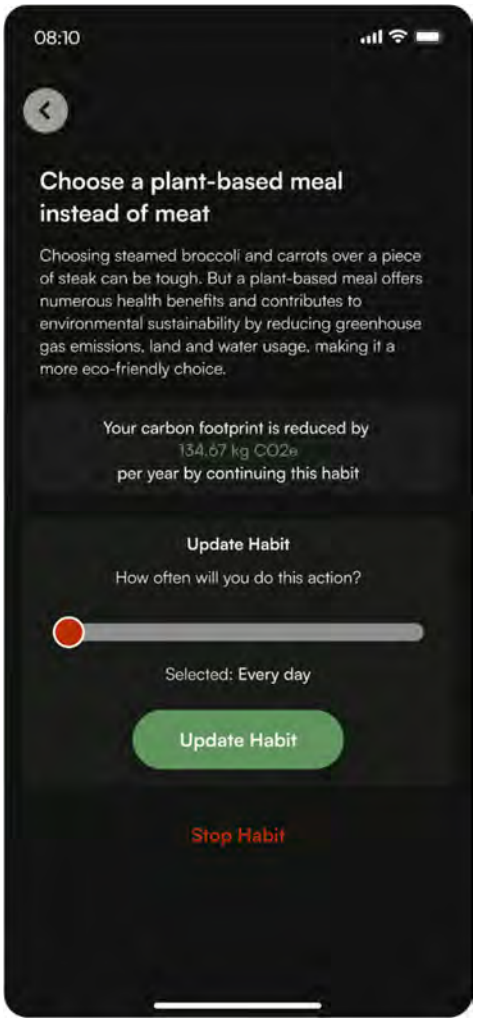


Figure 15

Figma Screen: Habit 1



CLICK FOR FIGMA PROTOTYPE

Section 4: Conclusion

Summary and Analysis

A disconnect between climate crisis and human being's emotion towards it was identified. The climate crisis remains as an abstract and distant concept for most people. People are unaware and neglectful of their own contributions to climate crisis. Even though there are existing carbon footprint calculators, people are not motivated to continue using it as there still exists a disconnect between emotions and climate crisis. This project aims to tie that gap through the use of music. A mobile application was developed, that tracks and calculates carbon footprint of the user based on 4 important metrics; household energy consumption, transportation, food and shopping/activities. This data is made into music using data sonification technology. The instruments and track tempo is adjusted and added according to the CO_2e of the user. The music is generated once every month, at the end of the month.

This allows the user to not only visualize their carbon footprint data but also hear it. The more carbon footprint a user has, the more urgent and faster the music will sound. This creates a sense of urgency, fear or guilt in the user. The response to hearing their footprint data music is yet to be studies and analysed.

Limitations

The data regarding the co-relation between the type of emotion and the notes in music have not been intensely studied or implemented due to time constraints and limited knowledge in music. There are studies that point to an association between certain emotions such as guilt, hope, anger to be linked to pro-environmental behaviour. But the link between the kind of music that can evoke specific feeling are not studies established in this paper as it requires extensive knowledge in music. The product can be redesigned to create results that are more immersive and impactful but deriving this connection between what emotion is felt when hearing a particular note or tune.

Areas of Improvement

The carbon footprint data collection needs to be completely automated so that the user does not have to remember to log in their dietary data every day.

Secondly, there could be a section for the user to interact with other users and share their EcoTune with each other, like a social platform. This allows the user to compare their carbon footprint data or EcoTune with that of other users to gain better understanding about where they stand in terms of their carbon contribution.

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