ClimaSynth: Enhancing Environmental Perception through Climate Change Sonic Interaction

Eleni-Ira Panourgia
Creative Exchange Studio
Film University Babelsberg
KONRAD WOLF
e.panourgia@filmuniversitaet.de

Bela Usabaev
Academy of Media Arts
Cologne
b.usabaev@khm.de

Angela Brennecke
Creative Exchange Studio
Film University Babelsberg
KONRAD WOLF
a.brennecke@filmuniversitaet.de

ABSTRACT

This paper presents a first prototype of *ClimaSynth*, a web-based interactive application that allows to creatively transform environmental sounds in response to climate change scenarios. *ClimaSynth* serves as an instrument for enhancing environmental perception through sonic interaction. The underlying algorithm uses real-time granular synthesis and web technologies to encode climatic effects in sound synthesis configurations in ways that express and speculate about change in future environments. *ClimaSynth* enables users to navigate and manipulate recorded audio data on a visual surface and produce new versions of environmental sounds. We discuss the design, implementation and resulting relationships between web-based sonic interaction and climate change impacts.

Author Keywords

Web audio, sonic environment, climate change, web-based interaction, audience participation

CCS Concepts

•Applied computing → Sound and music computing; •Human-centered computing → Web-based interaction;

1. INTRODUCTION

ClimaSynth uses web-based interaction and granular synthesis to manipulate environmental sound recordings in an attempt to express and speculate about change in future environments. The *ClimaSynth* application was developed as part of the research project Listening to Climate Change[1]. In this paper, we discuss the work related to the development of the first prototype of *ClimaSynth*. Our motivation is to create opportunities for communicating climate change impacts and relating to the environment differently, through the design of a widely accessible sonic experience [12].

2. BACKGROUND

Climate change directly impacts acoustic environments and shapes our experience in the world. Change in temperature affects reverberation in landscapes [13], biodiversity and acoustic phenology [18]. Paying attention to the ways in which environmental sounds are defined by their "spatial-environmental context" [7, p.42] can be particularly interesting for expressing climate change impacts. Processes of sonic interaction allow for structuring relationships and sonic material across spatial and temporal scales in ways that "extend creative action through participation and play" [7, p.43]. Our aim is to explore such relationships between acoustic and climatic effects. We turn to the expressive potential [2] of granular synthesis to delve into the microcosm of environmental sound recordings, manipulate and rearrange them into complex sounds [15] that have the capacity to communicate change in landscapes. The implementation was geared towards a web-based application to allow easy access on any device supporting modern web browsers.

2.1 Web Applications

Web-based applications depend on common web technologies such as HTML, CSS and JavaScript available in most contemporary web browsers. Their cross-platform implementation provides ubiquitous and standardized application development [10]. The Web Audio API[2] offers real-time and low-level audio programming [1]. Web-based music applications tend to focus on the "process of musical interaction itself" through simple interactive relationships and minimal user interfaces [10, p.212]. Creative coding frameworks such as Processing[3] and its web-based counterpart p5.js[4] can be combined with further web-technologies[5] to create widely accessible interactive sonic experiences [16] blurring the distinction between content and interface and overcoming the GUI-focused paradigm towards an audiovisual interaction approach [4].

User interfaces including visual surfaces offer opportunities for exploring sonic interaction through both auditory and visual dimensions. *Sound Canvas*[6] and *Lines*[7] use interactive visual elements on a canvas to synthesize sound based on drawing and mouse interaction [9] [17]. *Grain-*

[1] `https://www.filmuniversitaet.de/forschung-transfer/forschung/projekte/projektseite/detail/listening-to-climate-change-the-role-of-sound-and-new-media-formats-for-enhancing-environmental-perception`

[2] `https://developer.mozilla.org/en-US/docs/Web/API/Web_Audio_API`
[3] `https://processingfoundation.org/`
[4] `https://p5js.org/`
[5] `https://experiments.withgoogle.com`
[6] `https://experiments.withgoogle.com/sound-canvas`
[7] `https://gaudeamusscreendive.com/lines/`

NIME'24, 4–6 September, Utrecht, The Netherlands.

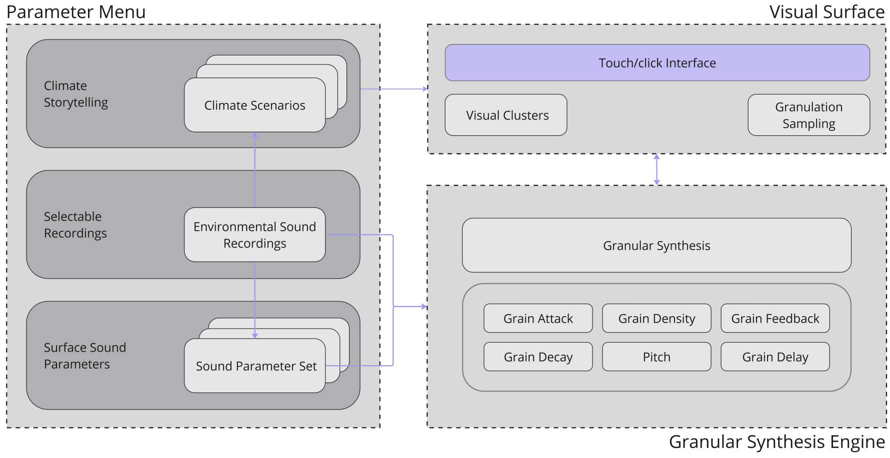


Figure 1: Components of *ClimaSynth*

Train uses real-time granular synthesis to transform recordings via a multi-touch drawing interface [20]. *Riverssounds*[8] allows users to navigate river flows and ecosystems within soundscape compositions using mouse interaction for moving through the waveform or changing playback direction [6].

2.2 Climate Change Scenarios

Climate change scenarios related to *ClimaSynth* concern the Brandenburg region, Germany, where we undertake recordings. These involve: a) temperature rise of 3-3.5°C by the end of 2100 and b) increase in precipitation of a 10-20 percentage in winter and a decrease of a 10-30 percentage in summer, according to the IPCC scenario A1B [5]. Following the climate model LUA-BB, low precipitation together with drought will impact water availability due to the "low soil water-holding capacity of the sandy soils typical for Brandenburg" [11, p.312].

These scenarios were further discussed with climate scientist Claas Nendel. We explored how sound can express drought through wet-dry contrasts and how familiarity with environmental sounds can influence their association with climate conditions. For instance, insect sounds or impact sounds on dry surfaces are often associated with high temperature and aridity [14]. Both directions are considered in the development of *ClimaSynth*.

Climate storytelling methods bridge climate change scenarios with imaginative and affective experiences by proposing "new ways of relating to the world" [8, pp.74-75]. Interacting with the sensory qualities of environmental sounds can offer opportunities for communicating climatic effects and reconsidering our agency by engaging with non-human perspectives [3].

3. CLIMASYNTH DEVELOPMENT

3.1 Core Components

ClimaSynth is made of a granular synthesis engine, a visual surface, and a parameter menu (Figure 1). At the heart of *ClimaSynth* is a granular synthesis algorithm adapted from the *Virtual Theremin* DMI [19]. The algorithm is implemented using the Web Audio API, which works in combination with p5.js to develop an audiovisual application. Real-time granular synthesis is activated by interacting with the visual surface. We investigate how the granular synthesis parameters and an interactive way for visual monitoring and control of the sound algorithm can be used to achieve mappings to climatic effects. A test set of three recordings undertaken in Potsdam and their associated scenarios are used in this first implementation. The *ClimaSynth* application is accessible on GitHub[9] and demonstrated in this video[10].

3.2 User Interface

ClimaSynth's interface uses minimal visual elements to emphasize the expressive sonic capabilities of the application [10]. The interface is visually reminiscent of natural elements including water drops, clouds or soil. An information page accessible on the top left of the screen contains a short description of the application and instructions. Climate storytelling prompts related to each sound recording appear as a short text upon selection of a recording from the drop-down menu proposing non-human perspectives of drought effects: for the file 'river water', 'river flowing differently becoming drier'; for the file 'birds near water', 'bird voices joined by insects'; for the file 'tree bark', 'trees readjusting their flexibility'.

By navigating the surface, users explore mappings between groups of granular synthesis parameters and different levels of climatic effects related to the prompts. The parameter groups are considered as 'environmental sonic states' and are represented as visual clusters. The interaction with the clusters can be further extended through the manipulation of the values 'spread' and 'areas' via a slider from the collapsible GUI component on the top right of the screen (Figure 2). The 'spread' value is reflected visually as an animated effect around the mouse or touch point. The 'areas' value shows the number of clusters around the mouse or touch point represented by black dots.

3.3 System Integration

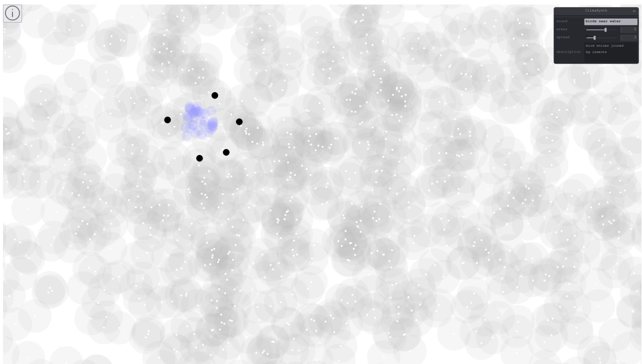
3.3.1 *Synthesis Engine*

Each recording is loaded in a global audio buffer whose length corresponds to the width of the visual canvas on the screen. The recording is sampled according to the po-

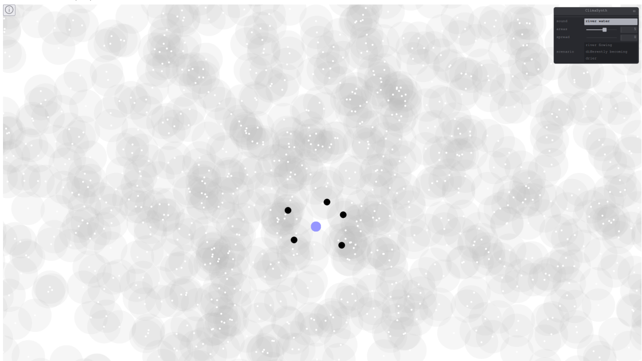
[8] https://riversssounds.org/

[9] https://ctechfilmuniversity.github.io/project_ClimaSynth/

[10] https://vimeo.com/942882544/ee41929ab0



(a) configuration with five areas and higher spread



(b) configuration with five areas and no spread

Figure 2: User interface of *ClimaSynth*

sition on the surface at each frame with p5.js referred to as 'granulation sampling' (Figure 1) and randomized within the range of the spread value. Grains are specified by grain attack and decay time. Feedback, delay, density and spread are applied to the grain. The granulation function is called at an interval specified by the density value of the current sonic state. The 'spread' parameter defines a range for the grain sampling position in the sound file (Figure 3). With zero spread value the grains are sampled from the same point, while a higher value allows for a broader selection of grains.

3.3.2 Audio-Visual Clusters

Three area groups are defined visually and sonically through clusters in relation to the intensity of the climatic effect. A gray-scale is used for visual intensity encoding. Darker areas are encoded as an extreme drought sonic state, light areas as a familiar state corresponding to the original recording and areas in between as an intermediate state. The 'areas' parameter specifies the number of clusters used for parameter interpolation around the interaction point (Figure 3). The parameter values of a sonic state are interpolated from the parameter values of the surrounding clusters using linear interpolation according to the weighted average of the distances between the clusters. Selecting one area makes the sonic states more disjointed and individually perceived, while with multiple areas they become more connected.

3.3.3 Environmental Sonic States

Each climate scenario is encoded as a configuration of granular synthesis parameters based on: a) contrasting environmental states, and b) transitions between familiar and extreme sounds. Table 1 gives an overview of the parameter configurations applied to the recordings. The parameter ranges for the grain envelope and the grain delay effects are given in seconds. Grain density is given as rate value of milliseconds defined between 0 and 1. The pitch range is given from 0.1 to 10 with 1 being the original pitch of the recordings.

The parameter mappings were defined by testing and experimenting with the three recordings using *ClimaSynth*. The extreme climatic effect is expressed by a longer grain envelope, high grain density and pitch values and a low feedback delay value to achieve a more drastic transformation of the original sounds from the domain of birds to insects, from water to sand or drier trees. For the intermediate effect we use a short grain envelope with mid-range feedback delay and pitch value, and lower grain density leading to transformed sounds between the extreme effect and the original recording for example, transitioning biodiversity conditions such as birds and insects sounding together. The familiar effect presents the original recording using a longer grain envelope, zero grain density, minimal feedback delay and default pitch.

Overall, we found grain density and pitch as the most prominent parameters in expressing climatic effects. High pitch and density values allow for heavier sound transformation, while a long grain envelope supports more homogeneous sonic textures. Feedback delay enhances the transitions between sonic states. We observed that the visual interface is very well-suited for performing sonic interactions based on granular synthesis parameter configurations.

	climatic effect	extreme	intermediate	familiar
parameters	grain attack	0.7	0.24	0.65
	grain decay	0.8	0.26	0.55
	grain density	0.99	0.65	0
	grain delay	0.3	0.4	0.1
	grain feedback	0.2	0.4	0.1
	pitch	9	4.72	1

Table 1: Granular synthesis parameter configurations for different climatic effects

4. CONCLUSION AND FUTURE WORK

We discussed the potential of web-based interaction with environmental sounds to express climate change impacts and introduced an approach to sonic interaction specific to the manipulation of field recordings using granular synthesis mapped to climatic effects. This approach offers a promising direction for conveying the complexity of climate change through rich sonic encounters with changing environmental states.

Further connections between climate change scenarios and sound will be explored through the integration of environmental and location-specific data in the UI. Creating more complex sonic environments by experimenting with a larger variety of recordings, interacting with multiple sound files and developing additional parameter mappings could expand the expressive capabilities of *ClimaSynth*. Sound synthesis and processing possibilities will be examined using the Tone.js[11] library. Elaborating on the visual design will help expand on the audiovisual relationships. We plan to run an evaluation study to assess the application.

[11] https://tonejs.github.io/

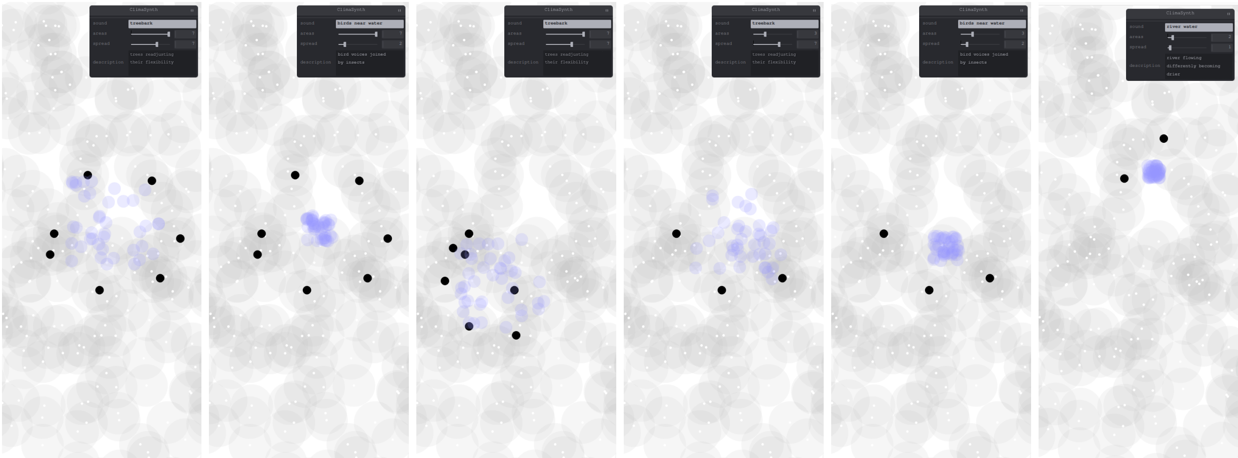


Figure 3: Different configurations of parameters ‘spread’ and ‘areas’

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6. ETHICAL STANDARDS

There are no observed conflicts of interest in this study. We acknowledge the environmental footprint of web and cloud technologies caused by high data access rates, real-time calculations and high-power consumption. By publishing *ClimaSynth* on GitHub, a platform that supports a sustainable culture of building software including the reduction and compensation of carbon dioxide emissions[12], we hope that the handprint of the application will be rather positive, raising awareness about climate change and making an impact on user behaviour. The current implementation and possible use cases of *ClimaSynth* will be further examined to ensure green software standards.

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