

Multisensory climate communication: Meaning-making through interactive audiovisual atmospheres

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Abstract

This demonstration presents rawTemp, an interactive multisensory data representation (MDR) that sonifies and visualises annual mean temperature data for Sweden (1900–2023). Users explore the dataset nonlinearly via a physical MIDI controller, triggering year-specific audiovisual states generated by a particle system and multilayered sonification. The system was designed through an iterative research-through-design process and evaluated through a qualitative study with ten participants. Findings show that the prototype elicited diverse emotional reactions, ranging from calmness to anxiety, and invited metaphorical and symbolic interpretations. Participants often described the data in non-literal terms, using imagery such as glaciers, galaxies, wombs and systemic collapse, highlighting the role of affect and metaphor in personal meaning-making processes. Conference attendees are invited to interact with the system, experience temperature change as an audiovisual atmosphere, and reflect on how multisensory design can support experiential engagement with climate data.

CCS Concepts

• **Human-centred computing**; • **Human computer interaction (HCI)**; • **Interaction design**; • **Systems and tools for interaction**;

Keywords

Multisensory data representation, Climate data communication, Affective interaction, Research through design, Sonification

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1 Introduction

To better understand complex data, data visualisation serves as a bridge between large datasets and human cognition [16]. By mapping the raw data to human sensory modalities through metaphors, viewers can recognise patterns and understand the raw data tables,

which are often described as abstract or non-tangible [17]. Traditionally, data visualisations have been created primarily for experts and analysts in order to reveal statistical relationships accumulated during a research process [15]. These traditional approaches are often non-interactive, require data literacy and prior subject knowledge to understand [7], and fail to captivate general audiences of non-expert viewers [6]. In response, especially within the context of climate communication, approaches such as data sonification [13] and multisensory data representations (MDRs) [5] have been proposed to better convey climate data to non-expert viewers.

By injecting an aesthetic, artistic flair into the design of data visualisations, we can potentially evoke stronger emotional responses and engagement among users [9], which in turn can help them embody and “feel” the data, presenting it as an experience rather than something passive. Within HCI research, it has long been recognised that emotion is a critical aspect of how users interpret, engage with and make meaning from digital experiences [11]. Since there seems to be a correlation between emotional engagement and personal internalisation of information [8], this demonstration presents rawTemp, an interactive audiovisual prototype featuring visualised and sonified temperature data from 1900 to 2023, developed through a research-through-design (RtD) process. Rather than optimising for analytical clarity, the system uses deliberate ambiguity [2] and cross-modal sensory mappings to support affective and interpretive engagement with temperature change over time.

2 Related work

Multisensory data representations (MDRs) are data representations in which data is not represented by a single sensory modality but by a combination of them, enabling users to experience the data in a more intuitive and experiential way [4, 14]. MDRs belong to a new class of data representation that encodes data in behaviour, emotion, functionality, performance, and affordance rather than merely aiming for clarity and speed [4]. Within climate communication, research critiques the overreliance on traditional data representations and emphasises the importance of experiencing data through sensory and emotional engagement [10]. Du et al. [1] argue that sonifications are particularly suitable for presenting time-varying information and that the usage of sound helps draw attention to patterns in the data, opening up for more mapping options without adding visual clutter [14].

Nan Li et al. [8] conducted controlled experiments showing that artistic climate visualisations elicited stronger emotions while being equally credible and informative to viewers. Kaufmann et al. [12] argue that interactive environmental art installations can



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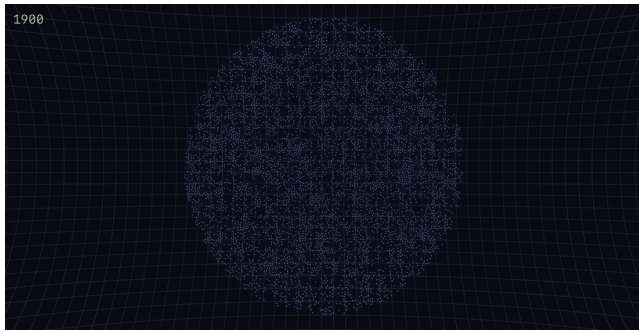


Figure 1: RawTemp showcasing a colder temperature value

trigger emotional responses that make viewers see environmental data in a new light. Within HCI, Gaver et al.'s [2] concept of ambiguity as a design resource suggests that introducing ambiguity can foster deeper reflection and personalised meaning. However, there remains a need for detailed accounts of how such systems are designed and how non-expert users actually experience them [5].

3 System design

The rawTemp system was developed iteratively over a three-month RtD process. Initial prototypes explored gesture-based interaction, GUI-based parameter control, FFT-driven audio-reactive visuals, and various visual mappings. These explorations informed two key design decisions: interaction should be minimal and direct rather than mediated by GUI elements or gesture recognition, which tended to draw attention away from experiencing the data through visuals and sound; and the sonification should use pre-rendered audio samples rather than real-time synthesis to ensure consistent recall across interactions, since generating sounds on the spot often led to performance issues, bugs and crashes.

3.1 Visual design

The visualisation, at its core, is a particle system built with C# in Unity, consisting of 3,500 self-organising agents or "boids". These boids move in accordance with emergent algorithmic behaviour, controlled by various custom movement scripts. This creates a natural-looking formation that prompts associations from the users. When a user presses a pad on the MIDI controller, each pad corresponds to one year in the temperature dataset. For example, when a user presses the key corresponding to the year 1900, that year's temperature data will be visualised through colour and movement, lower temperature values being represented by blue and barely any movement at all, while higher temperature values, such as the year 2020, are represented by the colour red and extremely eccentric movement. To achieve this movement, the temperature values were mapped to variables that control the boids' speed and amplitude. When the user releases the pressed pad, the system returns to the "default" mode, which is the dataset's mean temperature. A lens distortion effect was later added to achieve the circular layout to elicit stronger associations. The core visual metaphors are based on Wilke's [17] and Ware's [16] theories on static and moving patterns in visualisations, colour, and storytelling.

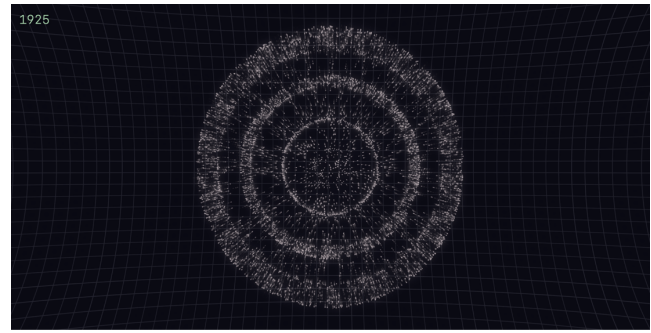


Figure 2: rawTemp showcasing neutral temperature value

3.2 Sonic design

The final sonification is multilayered, using the same generated MIDI data across four instrument-and-effect chains. The first chain produces white noise, in which the low-pass filter's cutoff frequency is modulated by the data. The second is an extremely high-pitched variation of a sine wave, where the pitch of the note and the amount of reverb applied are modulated by the data. Higher values have less reverb in order for the notes to be more easily heard, while lower temperature values apply more reverb to wash out the sound. The third channel is for bass, a simple sine wave with some harmonic content, where the pitch of the played note corresponds to the temperature data. The final sound, the leading sound, is based on an old Moog synthesiser. Here, just as in the other channels, the pitch of the note is modulated by the temperature data, but the generated velocity MIDI data is converted into modulations controlling the dry/wet amount and rate of a vibrato effect, creating heavier movement in the sound when higher temperature values are selected, as well as the amount of feedback on the chorus-ensemble effect, which contributed to creating an "alarm-like" sound when higher temperature values are selected. These mappings follow Hermann et al.'s [3] theories about recognising patterns in sound through pitch, velocity and filter modulation.

The sound sequence was resampled and split into separate audio samples, with each sample corresponding to a temperature value. These were then imported into Unity, and when a user presses a key, the corresponding sonified audio will play, ensuring tight audio-visual synchronisation without requiring external audio software during operation.

3.3 Interaction design

Ease of use was important, with the interaction as simple as possible. This is why controls through an eight-by-eight grid of pads on an Ableton Push 2 MIDI controller seemed appropriate. Each pad is mapped to one year in the temperature dataset (1900–2023), arranged chronologically across the grid. The Push 2 communicates with Unity via MIDI, triggering the corresponding audiovisual state when a pad is pressed. This interaction model supports non-linear temporal exploration: users can jump freely between any years, compare distant time periods, or move sequentially through decades. The core design considerations for the final prototype relied heavily on Gaver et al.'s [2] concept of ambiguity as a design

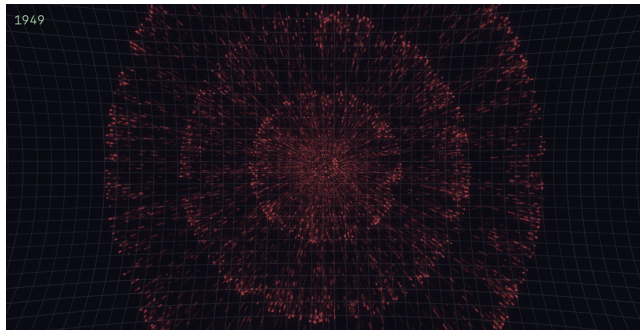


Figure 3: RawTemp showcasing warmer temperature value

resource. This deliberate implementation of ambiguity required several tests to balance, but in the end, it was decided that the only things visible on the screen when a pad on the MIDI controller is pressed are the year and the visualised temperature data.

4 Preliminary findings

User tests and semi-structured interviews were conducted with ten participants (mixed gender, aged 22–60) with no prior experience of MDRs or climate data visualisation research. The interview protocol was heavily inspired by Hogan et al.'s [6] Elicitation Interview Technique for capturing people's experiences of data representations. Thematic analysis of the interview data revealed six central themes.

Participants consistently described strong emotional reactions in relation to the visual and sonified temperature data. The cold years were often interpreted through metaphors of stillness and cohesion, while the warm years triggered a very different affective register, often described as chaotic, fast-moving and emotionally destabilising. The prototype's sonic mappings played a crucial role in conveying this emotional contrast, with hotter sounds linked to perceived threats or disruption, whereas the colder tones corresponded to serenity or stasis. All participants produced rich metaphorical associations, with the most vivid arising from interactions with the highest temperatures. Despite the prototype's lack of traditional numeric indicators, many participants reported a strong intuitive understanding, typically within the first 5 minutes of interaction. Users reported that the relationship between temperature and audiovisual representation was felt bodily, especially in pitch, movement in sound, visuals, and colour. The ability to move freely through over a century of temperature data fostered a sense of temporal perspective and helped users perceive long-term shifts. The prototype's openness and ambiguity were generally described as features rather than flaws, though they occasionally caused confusion when adjacent years were perceptually similar. Several participants noted that the multisensory format evoked more emotion than traditional data representations, while noting trade-offs with analytical clarity.

The result was a prototype that elicited strong associations among users, as each user saw and heard different patterns in the visuals and sonifications and could interact with it at their own pace in whatever way they deemed best.

5 Demonstration plan

Conference attendees will be invited to sit or stand in front of a monitor displaying the rawTemp visualisation and interact with the Push 2 controller, freely exploring Swedish temperature data from 1900 to 2023. Audio will be played through speakers to maintain an open, conversational setting rather than isolating users with headphones. A brief introductory explanation will orient attendees to the interaction model and dataset, after which they will be free to explore at their own pace.

The demonstration setup requires a table for the controller and laptop, an external monitor or TV (minimum 24 inches, HDMI input), powered speakers with a standard audio connection, and access to a power outlet. The demonstrator will provide the laptop running the Unity application and the Push 2 MIDI controller. No internet connection is required. The demonstration aims to offer attendees a first-hand experience of how multisensory interaction can transform abstract climate data into an affective and exploratory encounter.

6 Conclusion

This demonstration presents rawTemp, an interactive audiovisual representation of temperature data that fosters emotional and interpretive engagement. Through a Research through Design process, a sonified and visualised prototype enabled users to experience Sweden's temperature history through affective, exploratory interaction. Thematic analysis revealed that users responded with metaphor, emotion and intuitive understanding, highlighting the potential of artistic data representations to communicate climate data to non-expert users. While the system's ambiguity invited deep reflection and personal meaning-making, it also presented some challenges to clarity and navigation. These findings contribute to ongoing discussions in climate communication, affective HCI and creative data practices.

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