Echo Fossils: A Fossil-Inspired AI-Generated Ambient Soundscape Interactive System for Emotional Resonance and Emotional Soothing (Work in Progress)

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Abstract. This paper introduces *Echo Fossils*, a conceptual digital music instrument that integrates natural artefacts with AI-generated soundscapes to support emotional well-being and mindfulness. Inspired by the geometry of ammonite fossils, the design embeds generative sound into fossil-like forms, which allows users to interact through tactile gestures including touch, tap, and twist. These interactions activate ambient sound to mimic an oceanic and prehistoric environments, which creates a multisensory experience rooted in both physical and emotional resonance.

Keywords: Human-Computer interaction applied to music · Human-AI music co-creation · Music and Emotion.

1 Introduction

Previous research has demonstrated that music has a significant impact on supporting emotional regulation[2] and contributing to improved individual mental health by facilitating the achievement and maintenance of a comfortable emotional state through diverse musical engagement activities[1]. These benefits include mood enhancement[6, 7], stress and anxiety reduction[5], and increased self-awareness[3, 4]. With the development of Artificial Intelligence (AI), current studies have explored AI music creation systems in creative computation aimed at supporting and enhancing human creative abilities in music creation [8, 9]. Nature-based musical instruments such as rain sticks, ocean drums, and seed

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shakers provide benefits for emotional resonance, mindfulness, and emotional soothing. This research draws inspiration from natural instrument designs that incorporate elements from nature. Special design consideration was given to fossils, specifically the ammonite fossil, as an ancient species that lived in the ocean, to represent the connection between ancient ocean mysteries and current human heritage. As such, this study explores the integration of minimal design interaction with nature-based artefacts to generate AI-driven ambient soundscapes. From a technical perspective, ideally, when users touch, click, or twist the echo fossil, it will trigger the pressure sensor and collect input samples to produce AI-generated sounds with ocean-inspired ambient effects. The goal is to explore whether such interactions promote emotional soothing and mindfulness. This forms an exploratory design study that considers future design implementations to examine how nature-based artefacts can provide further unique journeys for users to support emotional soothing, resonance, and mindfulness practice with ocean sounds generated by AI. This research aims to explore the emotional resonance elicited through the design and interaction of the prototype, with a particular focus on user experiences with the artifact interface. We seek to understand how specific design elements influence users' emotional responses

2 Design Concept and System Architecture

2.1 Design Concept

Product Appearance The aesthetic is inspired by the ammonite, with its distinctive planispiral geometry shaped according to a logarithmic ratio, representing a concept of mathematical curiosity that can also symbolise the continual tracking of growth. Along the fossil's ribs, copper strips were attached. These metal parts represent the life that once existed inside the stone. This approach allows technology to camouflage as geological residues, while functionally serving as capacitive touch electrodes, and visually appears as mineralisation.

Interaction Design The gestural interaction aligns with Hornecker and Buur's facilitation framework [10], emphasising bodily engagement and spatial interaction while incorporating ritualistic qualities. Users interact by touching the fossil's rib-like structures, sound complexity increasing as more electrodes are touched. (see Fig. 1). The system architecture of *Echo Fossils* combines embodied interaction, embedded computing, and generative sound design to create an ambient co-creation system. The development is structured around two primary domains: hardware interface design and the audio generation pipeline.

2.2 System Architecture

Hardware Interfaces The fossil shell is fabricated using a composite material composed of papier-mâché and air-dry clay, chosen for its sculptability, light weight, and tactile qualities conducive to hands-on interaction. The geometry is

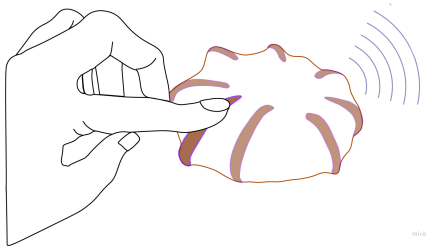

Fig. 1. When the user touches the copper foil, a sound is produced. The more the user interacts with the surface, the more complex the generated sound becomes.

based on the logarithmic spiral of an ammonite fossil. Each ridge of the fossil is overlaid by a $2.6mil$-thick copper strip; eleven strips are routed individually to the GPIOs of an ESP32 microcontroller.

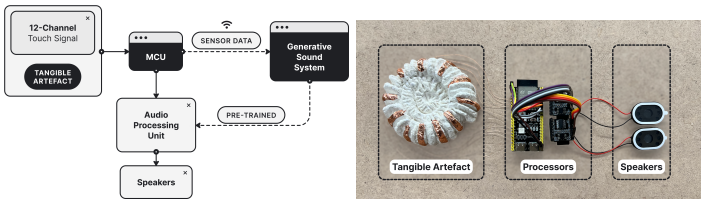

Fig. 2. Hardware data processing and exploded view diagram.

The microcontroller samples each channel's capacitance and interprets a $\approx 8pF$ rise as finger contact. It then counts the number of active pads and instructs two external audio processing units. Each is responsible for a dedicated playback track and its own $8\Omega 1W$ speaker concealed in the shell.

Audio Generation Pipeline To construct an immersive and interactive prehistoric soundscape, the system integrates AI-based Differentiable Digital Signal Processing synthesis [14] with spatial acoustic modelling and recursive recomposition. As illustrated in Figure 3, the process begins with capacitive tactile input embedded in a physical artefact referred to as the *Echo Fossil*, and recordings of oceanic environments (e.g., the sound of Atlantic tides). These input signals are processed to extract perceptually relevant audio features using components from the differentiable digital signal processing (DDSP) library and `librosa`. Specifically, the system extracts the fundamental frequency (f_0), corresponding confidence, and computes loudness (in dB) from root-mean-square (RMS) amplitude. Silent frames and numerical instabilities are addressed using numerical stabilisation techniques such as `np.nan_to_num()` to ensure compatibility with downstream synthesis processes (please access this project at [15]).

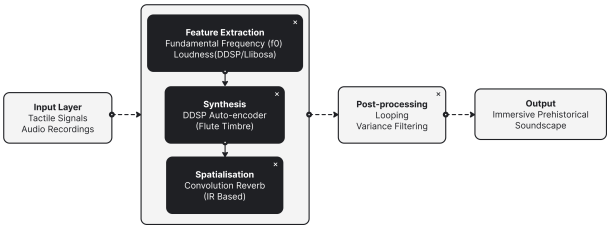

Fig. 3. Signal processing pipeline from audio input to immersive soundscape.

Each generated audio track is indexed by spectral density and spatial complexity, forming a hierarchy that maps directly to the number of electrodes being touched. As users interact with more surface area, they progressively unlock richer and more layered soundscapes.

3 Discussion and Future Design Direction

At the current stage, the AI model is limited to timbre transfer. However, going forward, this study plans to investigate how user interactions can be transformed into a more dynamic and interactive sound experience. In future implementation, this study will further develop the functions of additional interaction design, as mentioned in the initial phase, which enables users to engage with the artefact through click, rotate, tap, shake, and twist gestures. Consideration is also being given to the integration of temperature sensors, as when the user holds the device long enough, the device will further create rich soundscapes through harmonisation. Another development avenue is to further explore AI-generated sound creation. A demo of the system is available online [16].

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Disclosure of Interests The authors have no competing interests to declare that are relevant to the content of this article.

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