Sound Nest

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Abstract. Sound Nest is a tangible user interface (TUI) that transforms the ephemeral beauty of sound into an engaging and relaxing sensory experience, blending auditory immersion with hands-on interaction. Designed as a “nest” for nature sounds, the system enables users to place physical sound tokens—representing elements like waterfalls, bird songs, wind, or present-time ambient noise—onto an interactive board to craft customizable soundscapes. This playful interaction fosters creativity and mindfulness by making sound tactile, offering an engaging alternative to passive listening. Research highlights the benefits of nature sounds for stress reduction, with studies showing they can lower physiological stress markers and boost relaxation and creativity. By bridging the gap between digital audio and tangible interaction, Sound Nest offers a novel, multi-sensory approach to destressing, sensory play, and inclusive learning, turning the intangible into the tangible in a way that promotes well-being and creativity.

Keywords: RFID, TUI, Nature

1 Introduction

In a rapidly digitalized and industrialized world, humans are increasingly disconnected from nature. The therapeutic potential of natural soundscapes is well-supported by research across multiple disciplines. Studies have consistently demonstrated that listening to nature sounds, such as birdsong, rain, or rustling trees, can significantly enhance mental and physical well-being. For instance, a review in the Proceedings of the National Academy of Sciences synthesized findings from 18 studies and concluded that natural soundscapes reduce stress, improve mood, and enhance cognitive performance. These effects were observed across diverse environments and populations, with recordings of natural sounds proving nearly as effective as the real-world experiences they emulate [1].

Neurological studies have further elucidated the mechanisms underlying these benefits. Research from Sussex University employed MRI scans to reveal how natural sounds activate the parasympathetic nervous system, which lowers blood pressure, aids digestion, and promotes relaxation. This contrasts with artificial urban sounds, which tend to activate the body's stress-response systems [2]. Similarly, studies on "forest bathing" in Japan reported reduced cortisol levels and improved autonomic balance, underscoring the restorative effects of immersing oneself in natural auditory environments [3].

The cognitive benefits of nature sounds extend to improved memory, problem-solving skills, and concentration. Exposure to sounds like rainfall or birdsong has been associated with brainwave synchronization, which enhances cognitive functions and creativity [4]. Moreover, studies such as those conducted by Ryan et al. and Ratcliffe et al. have shown that listening to natural soundscapes can increase relaxation by 30% and reduce feelings of stress by over 20%, outperforming other mindfulness interventions like guided meditation apps [5,6].

These findings provide a robust foundation for the development of tools catering towards natural, immersive sonic experiences. There needs to be an interactive, accessible way to indulge in nature regardless of one's proximity to nature. Playing nature sounds from a streaming platform may be relaxing, but it is not customizable, fun, or interactive. By turning the intangible essence of sound into a tangible, interactive experience, users should be able to reap the well-documented benefits of nature sounds in an accessible and engaging way, making relaxation and sensory engagement a more integral and playful part of daily life while encouraging exploration and experimentation. More than a tool for passive listening, there is a need for a medium of creative expression, enabling users to design and personalize soundscapes in a way that blends art and play. Through this interface, users should be able to explore the beauty and complexity of sound, celebrating its tangible and customizable nature.

2 Methodology and Steps

The development of the Sound Nest system follows a structured process to ensure an engaging and functional tangible user interface for capturing and manipulating sounds. The methodology consists of the following steps:

2.1 System Concept

The Sound Nest system is designed as an interactive, sound-capturing interface that uses NFC/RFID technology to link physical figurines to corresponding nature-inspired sounds. The objective is for users to be able to craft their own auditory environment. People need a way to capture the unseen ambient noise around them and transform it into something physical that they can play with.

2.2 Implementation

1. **Hardware Integration**
    - The Sound Nest hardware consists of an acrylic board with an RFID reader positioned beneath the middle, a Wi-Fi-enabled Arduino for system control, and an FSR sensor to aid in capturing recordings.
    - RFID tags are embedded in 3D-printed figurines, which correspond to different sound elements, such as birds, waterfalls, and rustling leaves.
2. **Software Development**
    - A custom audio program is developed to detect figurines via RFID tags and trigger

corresponding sounds.
    - The program allows dynamic layering and real-time updates to the soundscape based on the placement or removal of figurines.
3. **Testing and Refinement**
    - The system undergoes iterative testing to ensure seamless interaction between hardware and software, smooth sound transitions, and an intuitive user experience.

2.3 Scenario Demonstration and Evaluation

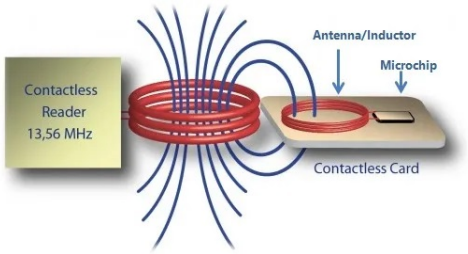
The project was developed over a three-week timeline:

- **Week 1:**
    - Order necessary parts and materials.
    - 3D print figurines and begin developing a basic audio program for sound triggers.
- **Week 2:**
    - Assemble hardware, connect the RFID reader, and test functionality with figurines.
    - Finalize software for syncing RFID inputs with soundscapes.
- **Week 3:**
    - Test the integrated system, conduct user testing, and refine hardware/software based on feedback.
    - Prepare final documentation and presentation materials.

User testing is conducted to evaluate the ease of interaction, creative potential, and overall functionality of the Sound Nest. Feedback is used to refine both the hardware and software components to deliver a seamless, engaging experience.

3 System Concept

The concept of the Sound Nest revolves around transforming sound interaction into a tactile, engaging, and customizable experience. Inspired by natural soundscapes, the system integrates physical figurines with digital sound triggers to create an intuitive platform for sound exploration. The Sound Nest operates as a dynamic tangible user interface (TUI), where users can build, layer, and deconstruct auditory environments by placing or removing RFID-tagged figurines on designated spots on the board while integrating sounds captured from their own natural environment.



The core idea is to bridge the gap between the physical and digital world as well as the seen and unseen by using RFID technology to associate each figurine with a unique sound, such as owl hoots, rainfall, or wind blowing. As figurines are placed on the board, corresponding sounds are activated and layered, allowing users to dynamically construct soundscapes. Removing figurines silences the related sound, offering an interactive and playful way to control the auditory environment.

Additionally, users should be able to capture the unseen ambient noise around them and transform it into something physical that they can play with. Users can use a net to “capture” specific environmental noises and lock them into a jar, which can then be placed in the Sound Nest to play the acquired sound. This system bridges tactile interaction with sound mixing to foster creativity and sensory engagement.

Unlike traditional sound mixing tools, which often rely on static controls such as sliders or buttons, the Sound Nest focuses on the physicality of sound interaction, making it accessible and engaging for users of all ages. Moreover, simply playing nature sounds from a streaming platform is uninteresting and lacks customizability; the Sound Nest offers a way for users to make the soundscape their own while adding ambient noises from their own environment that they like.

4 System Implementation

4.1 Hardware Design

The Sound Nest is built using an acrylic board equipped with an RFID reader embedded beneath the center. The reader detects RFID-tagged figurines, which are associated with unique sounds. These figurines, 3D-printed and painted to resemble elements of nature, serve as physical tokens for sound interaction. The board’s structure is supported by a basket, housing all circuitry, ensuring stability and

ease of maintenance, while also allowing users to feel they are “collecting” these different sounds.

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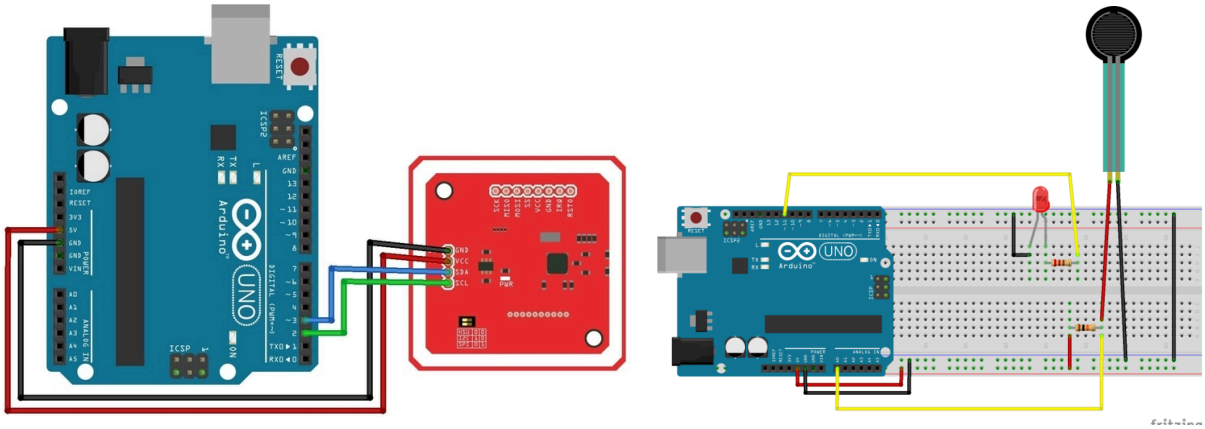
The system uses a Wi-Fi-enabled Arduino as the central controller, which processes the RFID input and communicates with the sound control software. The system also connects an FSR sensor to the capture net with LED lights to indicate when a recording is being made. When a user waves the net to capture ambient sound, they press the FSR sensor on the net handle, whose value triggers a recording function in the board’s processing sketch. When the user is done swinging the net, the recording stops and is stored as a playable audio file, alongside other nature sound audios.

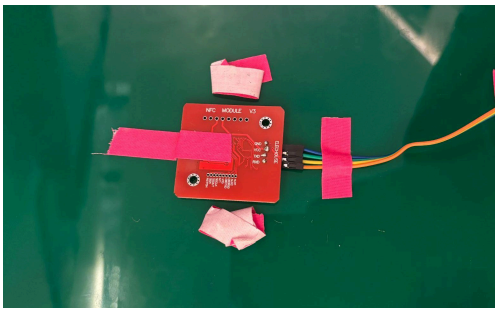
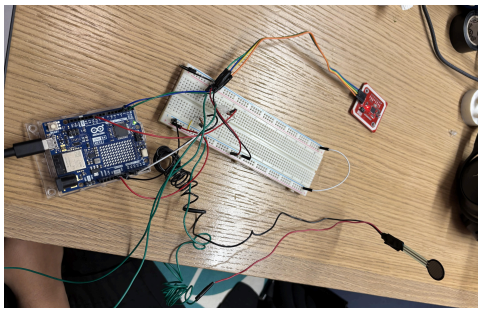


4.2 Software Framework

The software system is implemented in two parts: the Arduino sketch and the Processing sketch. The

Arduino sketch handles RFID reader inputs and sends relevant data to the Processing sketch. The Processing sketch manages sound playback and user interaction. Key functionalities include:

1. **RFID Detection**: The Arduino program detects the placement or removal of a figurine and communicates the corresponding data to Processing over a serial connection. When a tag is first read upon placement on the board, its associated sound plays. When the tagged figurine is removed from the board, the reader scans it again, stopping the sound on this second read.
2. **Sound Mapping**: The Processing sketch maps each RFID tag to a specific audio file and ensures real-time layering or removal of sounds as users interact with the figurines. The processing sketch also ensures that ambient sound is recorded into a .wav file when a user grabs hold of the "sound-catching" net, by reading the FSR value and determining when to record. Using the Minim library the sketch is then able to use the running computer's microphone to record into the .wav file to then be played upon the user's request.

4.3 Interaction Workflow

The interaction process is seamless and intuitive:

1. Users place RFID-tagged figurines on the center of the board. Each figurine's placement triggers its corresponding sound.
2. Users can dynamically add or remove figurines to layer or modify the soundscape. Removing a figurine silences its associated sound immediately.
3. Users can use a net to "ensnare" specific environmental noises and lock it into a glass jar, which can then be placed in the Sound Nest to play the acquired present-time ambient sound.
4. The system allows users to experiment with various sound combinations, fostering creativity and playful engagement.

4.4 Implementation Steps

1. **Assembly**:
    - Assemble the board with the RFID reader embedded under the acrylic sheet.
    - Connect the RFID reader to the Arduino and house the circuitry in the wooden basket.
2. **Software Integration**:
    - Upload the provided Arduino sketch to handle RFID input and communicate with Processing.
    - Configure the Processing sketch to process input data and control sound playback.
3. **Testing**:
    - Test RFID detection for accuracy and responsiveness.
    - Verify the correct mapping of figurines to sounds and ensure smooth transitions between soundscapes.

This comprehensive system integrates physical interaction with digital audio processing, providing users with a tactile, engaging, and customizable sound experience.

5 Scenario Demonstration and Evaluation

5.1 Scenario Demonstration

During a demonstration, the Sound Nest was placed on a table and made available for attendees to interact with. Users approached the device and were introduced to its basic functionality. Attendees were encouraged to combine and layer sounds by adding multiple figurines, and they could remove any figurine to silence its associated sound.

One participant began by placing a bird figurine on the board and listening to the cheerful chirping. She added a rain figurine, creating a layered soundscape, and then experimented by adding wind and rustling leaf figurines. Attendees found the system intuitive, engaging, and fun.

5.2 Evaluation

To evaluate the Sound Nest, attendees interacted with the device during a demonstration session and provided feedback via a structured survey. The survey assessed their experience, the intuitiveness of the system, and suggestions for improvement. Results showed high levels of engagement, with the majority of participants rating the interactive features as a 5 out of 5. Users particularly appreciated the hands-on experience, the layering of sounds, and the creative use of RFID-tagged figurines to trigger audio. Most found the experience intuitive and user-friendly, highlighting its accessibility and simplicity.

However, feedback also revealed areas for improvement. A few participants noted occasional inconsistencies in sound playback and suggested balancing sound levels for a smoother experience. Others proposed adding more sound options and integrating a digital visualizer with animations to enhance the system's sensory appeal. These insights will inform the next iteration of the Sound Nest,

ensuring a more refined and immersive experience.

6 Conclusion

The Sound Nest prototype successfully demonstrated the potential of blending physical interaction with sound creation to craft unique, layered soundscapes. By using RFID-tagged figurines and a tangible user interface, the system transforms the intangible beauty of sound into an accessible and creative medium. Participants found the device intuitive and engaging, with feedback suggesting it could appeal to a wide range of users for relaxation, education, or even musical experimentation.

While the current prototype effectively achieved its goals, it remains an early-stage system. Future iterations will address user feedback by improving sound consistency, adding more audio options, and exploring the integration of visual elements to complement the auditory experience. The overwhelmingly positive reception suggests that the Sound Nest has the potential to evolve into a fully realized product, offering a novel and interactive way to explore the world of sound.

References:

1. Gould van Praag, C., et al. "Mind-wandering and alterations to default mode network connectivity when listening to naturalistic versus artificial sounds." Nature, 2017.
2. Li, Q., et al. "The physiological effects of Shinrin-yoku (taking in the forest atmosphere or forest bathing): evidence from field experiments in 24 forests across Japan." Environmental Health and Preventive Medicine, 2010.
3. Ratcliffe, E., et al. "National Trust study into the impact of listening to Nature Sounds." University of Surrey, 2019.
4. Ryan, R.M., et al. "Restorative effects of natural environment experiences." Environment and Behavior, 2010.
5. A synthesis of health benefits of natural sounds and their distribution in national parks | proceedings of the National Academy of Sciences. https://www.pnas.org/doi/10.1073/pnas.2013097118.
6. Admin. 2023. Interfacing PN532 NFC RFID module with Arduino. How To Electronics. https://how2electronics.com/interfacing-pn532-nfc-rfid-module-with-arduino/#google_vignette.