

Waste Speaker: Reimagining Sound Through E-Waste

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Abstract

The rapid pace of technological development over the past several decades has led to an exponential rise in electronic waste, or “e-waste.” As devices become obsolete through cycles of innovation and planned obsolescence, the data once contained on these devices fades into obscurity. This project situates itself within ongoing discourses of material circularity and archival media, asking how obsolete technologies might experience renewal in new and creative forms. Specifically, this research explores the intersection of electronic waste, data sonification, and reuse through the design and development of *Waste Speaker*, a hand-held audio device built from discarded hard disk drives (HDDs). By translating latent data stored within these HDDs into generative sound compositions, *Waste Speaker* reconfigures the hard drive as both a medium and message of revival. In doing so, this project contributes to broader conversations around defunct media and sustainable design, positioning e-waste as a site of resurgence: no longer “waste,” and instead a medium for sensory engagement and critical reflection.

CCS Concepts

• Human-centered computing → Interactive systems and tools.

Keywords

electronic waste, defunct media, data sonification, creative reuse, HDDs.

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1 Introduction

As Jennifer Gabrys describes in her book *Digital Rubbish: A Natural History of Electronics*, “the digital revolution is littered with rubbish [3].” Over the last 50 years, everyday technologies have developed at a rapid rate. With these cycles of innovation, along with the planned obsolescence of electronic devices, the amount of electronic waste (e-waste) sent to landfills is increasing dramatically, posing

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Figure 1: Side by side comparison of Waste Speaker V1 (Fall 2024) and Waste Speaker V2 (Fall 2025).

a wide range of environmental concerns [12, 15]. Although some electronics can be easily recycled and disposed of with proper design and policy in place, most devices we use today are complex with integrated and mixed materials, challenging material recovery and reuse. This brings forth the following questions: *how do we divert end-of-life electronic devices from landfills? And, how can we recover and reuse discarded electronic devices and their functional components, exploiting potential uses they still have?*

As designers and artists, there is an opportunity to pursue the creative potential of salvaging, unmaking, and reusing discarded electronics. Reflecting on the resurgence of tangible practices, this work positions e-waste as a site where the discards of innovation can be materially re-encountered and re-imagined. Through processes of disassembly and reassembly, renewal and reuse, this exploration engages e-waste both as debris and as a material of convergence: inviting a rethinking of design practices and how we approach “making.” *How can we create work that provokes and encourages discourse about waste, consumerism, material chains, and life cycles? How can we think more deeply about life cycles and circularity in our own practices? How can we materialize new possibilities and directions for design?* The problem of waste extends far beyond just electronics and thus serves as a connective material for dialog across disciplines and domains of design. Ultimately, the goal is to contribute to a larger conversation about materiality and renewal, and how tangible, interactive encounters with waste can offer a means to connect with ecological and technological realities.

2 Hard Drives as Media Devices

As a form of embodied interaction, *sound* is an intriguing medium, as individuals can derive unique insights from the same listening experience (whether in the form of spoken word, ambient tracks, electronic noise, or music). In our early explorations, differing examples arose of designers crafting DIY speakers and sound devices from seemingly unrelated electronic components; Gijs Gieskes and his DIY synths [6], which utilize hard disk drives [4] and PC fans [5] as inputs for sound generation, emerged as a key inspiration.

Early research led to hard disk drives (HDDs) as a speaker output. Due to their compact form factor, intricate yet somewhat simple interior components, and ease of access as a waste stream, HDDs were an excellent candidate for a creative material resource. Hard disk drives were once ubiquitous products used in a variety of electronics, including computers, external storage devices, and video game consoles, to store and read data. However, for most uses, HDDs are now being replaced by their faster and more efficient counterpart, solid state drives (SSDs), leaving HDDs behind as outdated or “legacy devices [7, 9].” The abundance of HDDs in older electronics clearly opens up a unique opportunity for their reuse.

To break down a HDD into its basic components, a disk reading armature (or read/write head) with a copper coil (or voice coil) is sandwiched between two strong magnets. This armature stores and reads data from the disks or “platters,” with an electrical charge. This electrical current also controls the movement of the armature. One benefit of this system is that HDDs are “non-volatile,” meaning they can store data even when they are not powered. This makes the data accessible for longer periods of time (ideal for data backups).

In the HDD assembly, the copper voice coil is a key component that can be used for sound playback [8, 11, 13, 14]. Two pins of a larger pin interface, enable control over the armature. To achieve this, we connect the HDD’s pin interface to a custom printed circuit board (PCB). Then, and almost identically to how a typical speaker driver works, this voice coil can be exploited to convert electrical energy into mechanical energy, which in turn converts into sound by moving (or vibrating) the armature, compressing air, and creating sound waves that the human ear can hear.

3 Data Sonification

A particular point of focus in this project is the “obsolescence” of data. When a storage device is discarded or no longer in use, the data, like the drive itself, is now “obsolete”. One might ask, *what does it truly mean for data to become obsolete, or forgotten, and in what ways can this data be repurposed or composed? What are ways of representing the embodied memories of these devices?* These questions led our project to an exploration of the sonification of this obsolete data.

Data sonification [10] is the translation of data into audio, typically used across scientific or analytical processes. In creative practice, datasets can be transformed into sound or music to explore meaning, aesthetics, and perception. Musical structures which represent this information could potentially enhance the ways individuals engage in and experience data, particularly as a way to engage in the memories of obsolete devices and convert their histories into tangible representations.

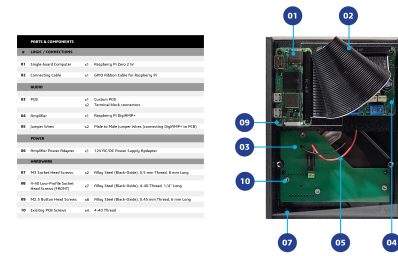


Figure 2: Parts and components chart accompanied by a labeled image showing the backside of the speaker

We prepared a generative Python script for data sonification [10] that works as follows. The script unpacks and gathers the file metadata (type, size, name length, and creation date) from selected folder(s) on any external storage device; in this case we used discarded, but functional HDDs, connected by an IDE adapter cable to a laptop. This gathered data is analyzed and, based on its metadata, each file is assigned to a MIDI note on a 49-note keyboard. These notes are then composed into a layered audio sequence. We provide a ‘piano roll’ interface to visualize the composed audio sequence and reveal how the file and its metadata are being translated into a particular note. The script then streams the MIDI sequence to the speaker for live playback.

4 Design & Implementation

The first iteration of this project, *Waste Speaker V1*, was presented at a studio-based exhibition at Carnegie Mellon University in the Fall of 2024. Inspired by Janet Cardiff’s *The Forty-Part Motet* [1], eight speakers were stand mounted and arranged in an enclosing arc, playing back a mixture of spoken word and ambient audio, creating an immersive embodied sound experience. *Waste Speaker V2* works to add additional layers to the interaction, including control over the audio through data sonification (as noted above in Section 3) and by making the object hand-held to offer a more personalized, intimate encounter with defunct media and data. In addition, *V2* has additional revisions for ease of assembly and better sound quality.

In its current implementation, *Waste Speaker* is an interchangeable HDD speaker system, with a custom kit of 3D printed parts, and a system of integrated electronics for audio playback. The case is designed to easily adapt to different hard drive models and can be modified to include other electronics and sensors. Mounted on the back of the case are two custom PCB boards, a Raspberry Pi Zero 2 W and a Raspberry Pi DigiAMP+ connected with a GIPO ribbon cable. The Raspberry Pi Zero acts at the logic interface between the speaker and the computer that is sending over the audio sequence. The DigiAMP+ board is used to amplify the audio signal which is fed into the voice coil on the disk-reading armature via a custom PCB that interfaces the necessary pins.

Finally, for the audio to be fully legible, we developed a custom 3d printed flaring horn. Like with a gramophone (another form of defunct media), a flaring horn is needed to project the soundwaves emanating from the vibrating hard disk armature [2]. A mounting plate is screwed into existing threads and clamps down on the portion of the armature around its rotating bearing. The flaring horn

is then friction-fit onto the plate, making its design interchangeable with different geometric variations. To complete the design, an acrylic insert slides into the back of the case for the protection and visibility of components.

With a compact and highly repeatable design, *Waste Speaker* offers artists and makers alike a tool for creative experimentation with defunct media and experiential audio. The speaker is highly customizable and could be arranged in a variety of ways, ranging from a desktop stand format to a light/mic tripod, to even a wall mounted system. In our current arrangement, a desktop stand acts as the speaker's resting place, and the audience is invited to pick up the device, observe the components in action (the moving armature and the electronic boards), look at their reflection in the mirror-like disc, and experience the generated audio. Audiences can also explore a selection of horn shapes and designs to explore how the horns change the way the audio is amplified and projected.

5 Ongoing & Future Developments

As an ongoing design and artistic research project, this work serves as both a prototype and a formwork for continued explorations in sound design, embodied interaction, and user experience with waste and defunct media. Future work could expand upon the experience through movement and bodily engagement, multi-speaker arrangements, and new modes of sound creation. As a handheld (or mounted) device, integrated sensors such as proximity, touch, or accelerometers could enable the sound to dynamically adapt in response to how it is held, moved, or approached, deepening the sense of tactile and embodied interaction. The spatial and experiential configuration of the device also invites further study: *how might multiple speaker units harmonize or respond to one another, or how might haptic feedback create a more immersive audio experience?* Finally, the sound generation system itself offers additional possibilities for exploration, ranging from comprehensive data sonification that transforms an entire device's contents into a "soundtrack," to audio generation that focuses on spoken-word compositions, potentially transforming files with text into generative poetic soundscapes.

In addition, a goal of this project is to make *Waste Speaker* available to others to reuse, adapt and expand upon. By releasing the 3D models, electronic specs, and generative scripts as open-source resources, we plan to stimulate creative experimentation with the possibilities of and for defunct and obsolescent devices. This approach frames obsolete technologies not as endpoints, but as sites of renewal through which new tangible possibilities and creative practices can emerge. As hard drives and other outdated storage devices are relatively affordable and accessible through websites like *eBay*, *Waste Speaker* could act as a starting point that many others build upon and reinterpret.

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