Fragile Instruments: Constructing Destructible Musical Interfaces

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ABSTRACT

We introduce a family of *fragile* electronic musical instruments designed to be "played" through the act of destruction. Each Fragile Instrument consists of an analog synthesizing circuit with embedded sensors that detect the destruction of an outer shell, which is destroyed and replaced for each performance. Destruction plays an integral role in both the spectacle and the generated sounds.

This paper presents several variations of Fragile Instruments we have created, discussing their circuit design as well as choices of material for the outer shell and tools of destruction. We conclude by considering other approaches to create intentionally destructible electronic musical instruments.

Author Keywords

NIME, Ephemeral Interfaces, Noise, Analog Audio, Synthesizers, Table-top Instrument.

ACM Classification

H.5.5 [Information Interfaces and Presentation] Sound and Music Computing — Methodologies and techniques, H.5.2 [Information Interfaces and Presentation] User Interfaces — Interaction styles, J.5 [Arts and Humanities] Performing arts, B.6.0 [Logic Design] General.

1. INTRODUCTION

From burning pianos to smashing guitars, the act of destruction has become an impactful idiom of modern music-making. From Rock'n'Roll to the artistic avant garde, performers have employed destruction to create shocking spectacle and stimulating sounds. In reaction to this trend, philosopher Stephen Davies argues that destroying an instrument is wasteful and disrespectful to the instrument [14] [15]. This view points to a common psychological phenomenon where well-crafted and useful tools, such as musical instruments, are awarded an elevated status among objects; some musicians even personify their instruments, like BB-King and his guitar Lucy.

Interestingly, Davies's argument resonates for the very same reason that instruments destruction has persisted in music-making. Watching and hearing destruction induces visceral feelings in the audience unachievable through conventional means, be it horror or glee, rage or release.Instrument destruction flouts the collusion between performer and audience [5],introducing immediacy and tension as the audience tries to anticipate whether the instrument will survive or be destroyed, pushing the boundaries between reality and performance. It also introduces a uniqueness to the performance as that instrument won't appear again and there's probably not going to be an encore, so the show is essentially over. At its most basic level, instrument destruction is expression of senseless violence, while at higher level it can represent a strong political statement and/or a unique theatrical spectacle that can actually be "played" to produce a somewhat controlled sonic manifestation.

This paper introduces a family of "fragile" electronic musical instruments designed to be "played" through the act of destruction. Each Fragile Instrument consists of a replaceable "sacrificial" shell enclosing a sound-synthesizing circuit. The circuit stays intact during the destruction of the outer shell and generates analog sounds based on embedded sensors. Destruction thus plays an integral part in both the spectacle and sound of each performance. Since the shell could be made from salvaged or recyclable materials, Fragile Instruments deliver the impact of instrument destruction without the waste of precious and expensive parts.

Figure 1: The photo on the album cover of the Punk Rock Band – the Clash featuring Paul Simonon who is smashing his bass guitar.

2. RELATED WORK

Intentional mistreatment of musical instruments was popularized by Rock'n'Roll and Punk musicians as a climactic spectacle during live performance. Guitar sacrifices have become the most iconic examples though a piano was reportedly the first "victim", set aflame by Jerry Lee Lewis in the 1950s as he performed his hit "Great Balls of Fire"

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[10]. Pete Townshend of The Who was the first to smash his guitar on stage in the 1960s [6]. Other artists introduced new variations on guitar sacrifice, including Jimi Hendrix, known to have smashed and burned his guitars, and Richie Blackmore of Deep Purple, who smashed his amplifier along with his guitar [2]. Stage sacrifice also extended to other instruments of the rock ensemble, such as the bass (Paul Simonon from the Clash), the organ (Keith Emerson from ELP) and drum set (Keith Moon from the Who).

Instrument destruction has found its way into a variety of other genres. In heavy metal Matteo Ravisio cites the Swedish guitarist Yngwie Malmsteen and keyboardist Christian "Flake" Lorenz of the German industrial band Rammstein [14]. Acid Mothers Temple is one of the new psychedelic rock bands whose unusual performances sometimes involve destroying older gear. The guitarist of the alt-rock band Muse reportedly destroyed a record of 140 guitars over a single tour. But the most bombastic of all may be the Japanese noise band Hanatarash, known for their extreme and dangerous live shows; once a venue was partly destroyed by a bulldozer [12].

Performance art of the post-war Avant-garde also featured instrument destruction. Here, no music was played in the traditional sense, but well-known instruments served a symbolic role as iconic cultural objects, and violence against them acted as artistic or political commentary to incite a strong emotional response. Such performances include Yoko Ono Piano Drop of Al Hansen and One for Violin Solo (1962) of Nam June Paik, both performances by Fluxus artists, and the "Piano Destruction Concerts" of Raphael Montañez Ortiz. More recently, Christian Marclay's video installation Guitar Drag (2000) explored similar themes [9].

Previous examples of instrument destruction prioritized the visual and symbolic dimensions of spectacle over pure sound. While the total effect of instrument destruction cannot be divorced from its visual and symbolic meaning, some musicians have experimented with destruction as a vehicle to explore unusual sounds. Composers Annea Lockwood and Diego Stocco recorded pieces featuring the sounds of burning and drowned pianos [8]. Jazz pianist Yosuke Yamashita performed on a burning piano, exploring changes in sound through his improvisations as the instrument gives in to flames. These destructive acts can be linked to extended piano techniques and prepared piano pioneered by post-war avant-garde composers such as Stockhausen, Cage, and Cowell, which have been labeled as "mistreatment" by purists [1].

Figure 2: Japanese Jazz Musician Yosuke Yamashita performing on a burned piano.

Destruction for the sake of music can also be found outside of traditional instruments. Tchaikovsky's 1812 Overture, often performed for the American Independence festivities features 16 canon fires, for both sound and spectacle. In the 1940s, musique concrète [18] composers also experimented with destruction, such as Concrete PH of Iannis Xenaxis, which featured sounds from burning charcoal.

Fewer examples of destruction can be found in the world of electronic musical instruments. Most have been centered on creating interesting sounds rather than performative spectacle. Louis and Bebe Barron built overloaded circuits with parts that exploded to produce the unique sounds for the film Forbidden Planet (1956)[7]. More recently, "circuit benders" manipulate ready-made electronic devices in unintended ways to generate interesting effects. However these performances are not readily perceived as "device mistreatment" through the physical gestures of playing [19].

3. DESIGN

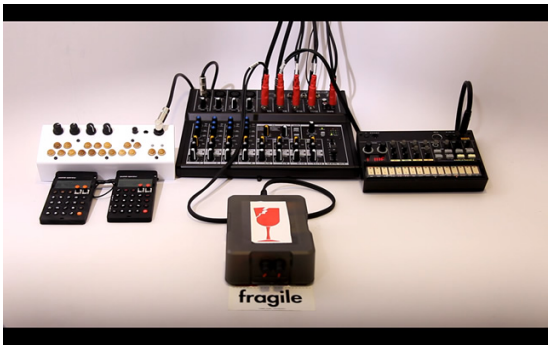

Figure 3: A series of table-top electronic music instruments feeding into a mixer. The instrument with a fragile sticker in a salvaged plastic box awaits its fate.

Our work explores how the new electronic musical instruments could be designed to allow control over both the spectacle and the sound of their destruction. These "fragile" instruments each consists of three main parts: a circuit, an enclosure, and tools for destruction.

Analog electronics lies at the heart of every fragile instrument. Each consists of one or more sensors (e.g. photoresistors, piezos, force sensitive resistors), whose output feeds into one or more analog sound-synthesizing circuits. The sensors detect the destruction that occurs and modulate the output of the synthesized sounds. This circuit is well-protected by an enclosure and stays intact during destruction.

Enclosures are the actual sites of destruction. They are meant to be destroyed each time and can be made from low-cost, recyclable, or salvaged materials such as plywood, plastic, or cardboard. Multiple destructible enclosures can nest within each other, like Matryoshka dolls, where the sensors could be distributed among each layer boosting the overall performance and sound. To better protect the circuit, the innermost enclosure should be more robust, unlike the outer ones.

The tools of destruction can also be included in the design of a fragile instrument. While all fragile instruments can be destroyed by bare hands, optional tools such as hammers, electric drills, and chainsaws, can add to the spectacle and soundscape of a performance. Like drum-sticks, guitar picks, and xylophone mallets for traditional instruments, these tools enable different ways of "playing".

While a large number of instruments can be created by mapping some aspect of a performer's gestures to sounds on a computer [17], we imposed the design constraint that our first set of instruments remain within the domain of analog electronics and everyday objects. We imposed this constraint for the following reasons:

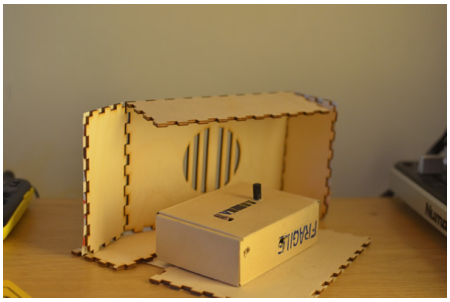

Figure 4: Nested boxes featuring a Laser-cut box "protecting" a cardboard box that encloses a metallic box carrying the fragile board.

- **Latency**: Purely analog circuits introduce no-noticeable latency in the translation between sensor signals and sound
- **Expressivity**: Analog electronics is known for its "richness" in synthesized sounds in the world of modular synthesizers [16]. The direct connection between sensing and synthesis enables subtle gestures to affect the resulting sound (e.g. the Theremin)
- **Unpredictability**: Analog circuits often yield surprising results. Because destruction is chaotic, we wanted our instruments to sound different each time they are "played".
- **Affordability**: One reason electronic musical instruments are not often destroyed may be due to their high cost. Fragile Instruments use only commonly found, inexpensive components that can be easily replaced. Hence limiting financial damages.
- **Portability**: All fragile Instruments are designed to be self-contained and "plug-and-play", requiring no special wiring. With the addition of wireless microphone transmitters, fragile instruments can be made untethered, which allows them to be thrown across the stage or smashed against walls.

4. PROTOTYPES

Numerous fragile instruments can be created based on variations in circuit design, enclosure materials, and tools used. We now describe some prototypes that we have explored.

4.1 Circuit

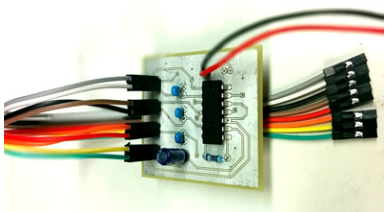

Figure 5: Fragile board that accepts up to 4 different input sensors.

Several digital logic gates live at the core of every fragile circuit. We experimented with several variations of the circuit to yield different sounds. The simplest circuit is the oscillator and it requires only three components: a variable resistor, a capacitor, and an inverting Schmitt trigger (74HC14). The variable resistor serves as the sensor that affects the frequency. Any part with variable resistance could be used, such as a photoresistor, force-sensitive resistor (FSR), flex sensor, or resistive fabric. The frequency of the oscillation is calculated and approximated using the formulas below.

$$f = \frac{1}{RCLn(\frac{V_{T+}(V_{cc}-V_{T-})}{V_{T-}(V_{cc}-V_{T+})})} \quad (1)$$

$$f = \frac{0.82}{RC} \quad (2)$$

In equation 1, R is the resistance of the variable resistor in Ohms and C is the value of the capacitor in Farads. The natural logarithmic part of the equation calculates the amount of hysteresis induced by the circuit at a given supply voltage (VCC) and could be retrieved from the Fairchild datasheet [4]. The simplified frequency for our condition is calculated in equation 2.

For example, a photoresistor of value 100K Ohm, coupled with a 0.1 uF Capacitor would give a frequency ranging from 80 to 800Hz which is an ideal frequency for audible square waves. Some of our circuits were powered by 9V batteries and regulated with an LM7805 linear voltage regulator chip powering the inverters with 5V DC. Other circuits were powered directly by 3xAAA batteries providing the inverters with 4.5V DC.

Another type of fragile circuit contains oscillators made by dual-input Schmitt trigger-based NAND gate from the CMOS 4000 series (CD4093), where the frequency could also be approximated using the simplified equation 2. Frequency modulation is achieved by cascading an even number of dual inputs gated oscillators, which results in more complex, chaotic behavior that translates to more interesting sounds. Even more variability and unpredictability of sound can be achieved by introducing feedback between the gates coupled with tilt-switches or cheap accelerometers.

These oscillators can also be used in conjunction with an ISD1600B. Allowing the control of the playback speed of this chip that can record few seconds of audio when coupled with a tiny electret condenser microphone. The sensor controlling the RC component of equation 1 and 2 shapes the interaction of any fragile instrument with such a sampler circuit. For example, we can create an instrument that screams "ouch!" when it is struck based on how it is struck.

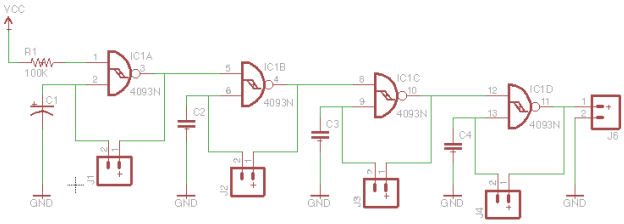

Figure 6: Schematic showing 4 cascading gated oscillators used in various fragile instruments inspired by Nicolas Collins's *Handmade Electronic Music* [3] and Benoît Maubrey's work on the Audio Ballerinas and Geishas [13].

Our last fragile circuit makes use of the acoustic waves generated by the force of impact during destruction, which resonates the inside of the enclosure and vibrates a ceramic piezo pickup disc. The audio signal recorded by the smash is then synthesized and sampled back at speeds controlled by the samplers oscillator. One sound transformation we explored involves a ring-modulator and a reverb effect.

4.2 Enclosures & Tools

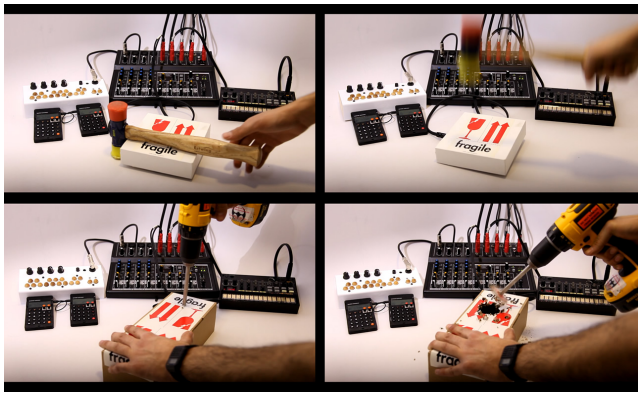

Figure 7: Two fragile instruments: the top one generates electronic sounds of misery and pain each time it is hit by the hammer. The bottom is being destroyed to the point of no return by a drill. More holes in the box lead to higher frequency changes.

In our prototypes, our circuits have been encased in two layers of enclosures. The inner layer is a metal box with small holes that allow some light to affect the photoresistors. The material of the outer enclosure depends on the nature of the circuit and decides which tools should be used to perform the destruction ritual. For instance, we used an acrylic box to enclose our photosensitive instruments to enable them to be "played" by hand — the shadow cast on the box affects the sound of the instrument. For cardboard outer enclosures, a drill would be more convenient and convincing for destruction.

The sensors of a circuit also help determine the material of the outer enclosure and tools to be used during performance. FSRs, for example, call for percussive actions, which result in discrete, rhythmic sounds. Any hammer or blunt object is perfect for such an interaction, including the performer's fist. Circuits involving Piezo pickups are usually made out of cheap salvaged plywood since they resonate more than acrylic or plastic boxes.

5. FUTURE WORK

For the instruments explored in this paper, we avoided computer based electronic music. But if we remove that design constraint, this opens up a variety of computer-based fragile instruments that could also generate interesting spectacles. For instance, the sound of the instrument could be digitally synthesized in low-cost embedded Linux/GNU microcomputers such as the Raspberry Pi Zero or the BeagleBone, as previously explored by the D-Box - an ultra low latency hackable digital instrument [20]. In real-time the sensor data could be mapped to different sounds or patches.

We would also like to explore the idea of embedding a fragile instrument inside an actual instrument like the electric guitar. These fragile Hyperinstrument [11] would amplify, distort and sample the sound of the acoustic destruction of the instrument and perhaps re-synthesize it.

Finally, we would like to explore collective types of instrument destruction that involves engaging the audience in the act. Untethered fragile instruments thrown on stage into an excited crowd might have the potential of creating memorable moments between the musicians and their audience, and perhaps form a type of socially galvanizing group therapy during difficult times.

6. CONCLUSIONS

We presented the concept of electronic instruments that are played through the act of destruction. This paper explored one approach to create such instruments — as reusable analog circuits surrounded by a "sacrificial" shell whose destruction is detected by sensors to affect the synthesized sounds. The destruction of our Fragile Instruments delivers an impactful spectacle and striking sounds without the waste of expensive materials.

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