Plink Jet

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ABSTRACT
Plink Jet is a robotic musical instrument made from scavenged inkjet printers and guitar parts. We investigate the expressive capabilities of everyday machine technology by re-contextualizing the relatively high-tech mechanisms of typical office debris into an electro-acoustic musical instrument. We also explore the performative relationship between human and machine.

Keywords
Interaction Design, Repurposing of Consumer Technology, DIY, Performing Technology, Robotics, Automation, Infra-Instrument

1. INTRODUCTION
Plink Jet is a robotic musical instrument made from scavenged inkjet printers. The mechanical parts of four inkjet printers are diverted from their original function, re-contextualizing the relatively high-tech mechanisms of typical office debris into musical performance. Motorized, sliding ink cartridges and plucking mechanisms play four guitar strings by manipulating both pitch and strumming patterns mimicking human hands fingering, fretting, and strumming a guitar. Plink Jet is designed to play in three modes: automatic (played by a micro-controller), manual (played by a musician), or a combination of both. A musician can choose varying levels of manual control over the different cartridges (fretting) and string plucking speeds (strumming), while improvising with preprogrammed sequences of Plink Jet.

2. INTERFACE
Plink Jet is designed to play guitar strings both manually and automatically. The interface consists of four toggle switches, four three-way switches, four dials, a single six-position rotary switch and a single power switch. Each of the four toggle switches and three way switches is associated with a single ink carriage. The rotary switch allows the user to select different pre-programmed patterns while a carriage is under automatic control.

2.1 Fretting
The guitar strings are strung across the printer mechanism where the optical sensor used to be. Cartridges slide up and down the strings and touch the strings just enough to change the pitch, similar to a slide guitar. The farther away the cartridge is from the plucking mechanism, the lower the pitch of the note.

Each carriage is controlled by a toggle switch and a 3 way switch. Toggle switches control whether the associated inkjet carriage is under manual or automatic control. While under manual control, the back-and-forth motion of each carriage is controlled by a three-way switch. While under automatic control, the carriage is controlled by a micro-controller containing programmed patterns of movement.

2.2 Strumming
The guitar strings are plucked by motors with a single thin metal strip that strikes the string as it rotates around. Four dials control the speed of the strumming motors. Control over the strumming motors exists regardless of whether the associated carriage is under manual or automatic control.

2.3 Amplification
Inside each ink cartridge is a piezoelectric microphone used to pick up the sound of the plucked guitar string as well as the ambient sounds of the sliding cartridge. In many ways Plink Jet is an elaborate guitar, and like an electric guitar it has a single quarter-inch output jack which allows it to be connected directly to a guitar amplifier.

3. TECHNOLOGY
The printer carriages and motors are from four inkjet printers. The controlling circuits and electronics are custom-designed. The optical encoder of each inkjet printer has been removed and replaced with a tunable guitar string that uses actual guitar tuning mechanisms built into the machine.

3.1 Circuitry
While under manual control, Plink Jet's circuitry is completely analog. The only digital element is the micro-controller used in automatic mode.

3.1.1 DC Motors
A DC motor connected to an H-bridge chip controls the back and forth movement of each carriage. While in manual mode, the three-way switch controls the H-bridge with 5VDC. While in automatic mode, the H-bridge is under the control of the micro-controller.

3.1.2 Stepper Motors
The strumming mechanism is driven by stepper motors, normally used for the docking procedure of the ink carriages. Each dial is attached to a potentiometer which controls the speed by changing the voltages on an oscillator chip. The oscillator signals are connected to hex divider chip, that acts as a stepper driver. The stepper signals are then relayed through a Darlington array before triggering the stepper motors.

3.1.3 Micro-controller

Plink Jet uses an ATMEGA168 chip containing six pre-programming patterns to control the fretting when a carriage is in automatic mode. A six-position rotary switch selects which pattern to use. When a carriage is in automatic mode, the ATMEGA controls the associated motor's H-bridge.

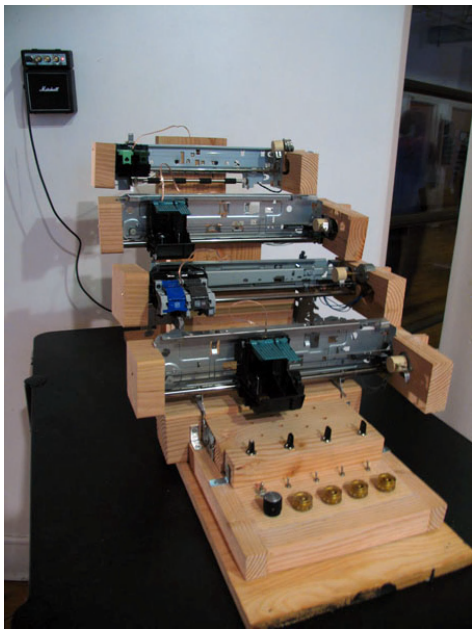

Figure 1. Plink Jet at the ITP Winter Show 2007

4. EVERYDAY MACHINES AND MUSIC

The repurposing of consumer technology is a growing trend for artists and technologists in the DIY genre exploring circuit bending, hardware hacking and retro-engineering [6]. Artists who have used the mechanics of printers for producing sound include Paul Slocum with his dot matrix printer and Eric Singer's printer/scanner-inspired musical instrument, GuitarBot. The innovative American composer Harry Partch built many of his instruments out of trash and his own carpentry. Plink Jet emerged from the process of hardware hacking and could be considered an *infra-instrument*, a concept developed by John Bowers and Phil Archer. Infra-instruments are often created by taking a non-instrument and finding the instrument within [1]. With Plink jet, we have found the infra-instrument within the inkjet printer.

Machines are built to be reliable. When they no longer function consistently, we quickly upgrade to new machines and readily discard the old. But usually, these discarded machines are not dead. Their mechanisms still function, though perhaps not as originally intended. Taking apart these discarded machines is an opportunity to appreciate them for what they are, as opposed to what they are intended for; such is appreciating a printer for its mechanics, rather than its ability to print. Combining the parts of these machines with parts of musical instruments is a way to see their operative similarities and learn how they work through sound.

Inside an ordinary inkjet printer are the same toy-like, clockwork mechanisms that have delighted people and sparked imaginations for centuries. When we made Plink Jet, we took these mechanisms and combined them with guitar. Now we not only see the back-and-forth motion of the inkjet cartridge, we *hear* it. Adding a guitar string highlights the design structure inherent in a printer by relating pitch and rhythm directly to its mechanics. The mechanical relationship between human fingers fretting a guitar string and an inkjet cartridge riding an optical sensor is heard in a musical scale. We did not take apart printers to make a guitar. Plink jet is a hybrid. Both printer and guitar are heard. The pickups not only amplify the guitar strings, but how the guitar strings sound within a printer. The ticks, clicks and hums of the printer mechanisms are amplified expressiveness, like slapping the neck of a guitar or rubbing its strings. There is respect for the original sound of the printer and it remains present in the new invention.

Plink Jet is part of a long tradition of re-appropriating office technology to create music. As early as the 1970s, computer technicians learned how to use the early IBM 1400 mainframe computer series to generate music- "… a purpose for which this business machine was not at all designed. The method was simple. The computer's memory emitted strong electromagnetic waves and by programming the memory in a certain way and by placing a radio receiver next to it, melodies could be coaxed out - captured by the receiver as a delicate, melancholy sine-wave tone." [3]. Technicians also learned to use the IBM 1403 printer under the control of an IBM 1401:

> Clever engineers figured out what line of characters to print to make a noise at a given pitch, and how many times to print that line repeatedly to sustain that pitch for a given duration. In other words, the printer could play musical notes. All that was needed was a program for the IBM 1401 computer system that read in a deck of punched cards, each card containing a single note of melody, and then played the melody on the printer. The tempo could be adjusted using the sense switches on the computer console. [2]

Future iterations of Plink Jet could include more printers, more precise levels of user control, different stringed instruments, greater levels of automated control, and more precise tuning and plucking mechanisms. But decisions that concern the number of printers used or the use of guitar strings rather than violin strings are ultimately irrelevant to the nature of Plink Jet. Plink Jet is an experiment, a way for us to learn and have fun with mechanics though sound. Plink Jet is not yet a fine-tuned and finessed robotic instrument. It is an illustration of deconstruction and reconstruction in process, alive with imperfections. It will be interesting to see how future versions Plink Jet can change our relationship to the original machine. The different sounds we are able to coax out of more printers could inspire new observations on how machines work and teach us more about what we desire in their performance.

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5. STRUCTURE AND IMPROVISATION

Intuition plays a powerful role in how and why people perform. A human listens to his or her performance and is able to react and make constant changes. A machine does not have this self-awareness; it simply follows prepared instructions. We do not want our machines to improvise. We want a printer to function as a printer, printing exactly what we want when we want it. If it does not do what we expect, it becomes useless to us. With Plink Jet, human improvisation plays with the machine and transforms the predicable function of a printer into a unique and irreproducible performance.

A musician playing Plink Jet is like a pianist playing a player piano. Two performance operations are occurring simultaneously. There are the programmed, ordered movements of the machine itself, and there are the improvised decisions of the user regarding levels of automatic and manual control and his or her reactions to the precise mechanical patterns. The Player Piano is one of the first examples of an automatic, mechanically played musical instrument, but early player piano rolls lacked expressiveness when played because they were created by hand directly from the music score [4]. Electronic or machine music often evokes very different emotions as opposed to human-performed music because of its super-human precision. The combination of these two musical aesthetics (prepared and improvised, machine and human) expresses a tension in our relationship with machines. Reflecting upon the interplay between a mechanical presence and human player, Eric Singer of LEMUR has said "I believe it is an entirely new experience for the human players. The robots create a physical, responsive presence (unlike synthesizers) which can profoundly affect the humans interacting with them. Because they move as well as sound, they take on a personality of sorts, and inspire the human players in a unique way." [5] Numerous options for playing Plink Jet between manual and automatic control opens a dialog between the player of Plink Jet and the robotics of the mechanisms themselves, and a performance broadcasts this dialog between machine structure and human improvisation.

6. ACKNOWLEDGMENTS

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