OttO, The Generative Critter - An MFA Thesis Project

Grant C. Bouvier

Brooklyn College - Sonic Arts, MFA

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www.grantbouvier.com/devices/otto

We live in an era when it seems like everything is computable. One could argue that the artistic landscape that sits before us has never appeared as vibrant and adventurous as it does today, as so many traditional boundaries have melted away in the name of digital art and new media. Furthermore, traditional power structures in art and technology have begun shifting towards more democratic means since the dawn of the new millenium. Open source, a concept that took root during the advent of the digital era, suggests that technology be accessible and free to users who want to adapt, evolve, and utilize it. Much of the new artistic and audio landscape has been shaped through the of digitization of content, the laptop (and smartphone) revolution, and affordable broadband internet access across most of the developed world. Far more words can be spent describing this new digital era that we live in, and many more eloquent critics and theorists have devoted their careers to doing just that. The state of technological affairs is brought up here and now simply to illustrate the point that art, music, and the technology used to create them have entered uncharted territory in the twenty-first century as computational power is now immense even in the cheapest, smallest packages.

We have seen many young movements, theories, and aesthetic ideologies grow and galzanive around affordable technology and the digitized world. *OttO, The Generative Critter* is an attempt to explore one of the many frontiers of our new digital existence with an emphasis on accessibility and open source. With a few specific ideas underpinning the whole work and several other secondary concepts orbiting it that are nonetheless important to the aesthetic result, this project serves as an important confluence of the DIY music ethos and the radical frontiers made available for exploration via cheap and readily available digital technology. *OttO* is both a composition of generative music and a hardware platform for developing generative music more broadly. It is at once a consumer product, an audio playback device, a sonic instrument, and an 'art object'. It is meant to be playful and fun, but it also opens wide the doors of creative freedom to anyone willing to dive into the code for themselves. The most important feature of *OttO* is its affordability and open source design. In an age of quickly obsolete gadgets that clutter, *OttO* is a digital creature that begs to be explored sonically, visually, and computationally.

To better understand what *OttO* is, perhaps it would be wise to establish a working definition of generative music. Brian Eno is widely considered to be responsible for the popularization of the term 'generative music', which can most effectively be described as music that is systematic in nature and is ever changing and evolving over time in terms of composition, sound, or both. While this definition is vague, it may help to think of generative music related to its most elementary example: the humble wind chime. Though many associate generative music and composition with computers, the earliest examples of generative sound composition come from the sonification of elemental forces via fixed material instruments. The resonating tubes (or other material objects) hung as a part of the wind chime will offer a limited palette of sonic textures and pitches, but depending on the placement of the chimes and weather conditions, a near limitless number of aural outcomes become possible based on how they swing, knock against each other, and combine their resulting sounds in a given acoustic space. This is the essence of generative music: to create a system with a few fixed elements, and allow the variability of the system to unfold over time, creating complex sonorous events the likes of which will never be heard the same way twice.

Obviously, the computational and quantifiability of generative music and its preoccupation with systems lends itself very naturally to digital computers and interfaces, which serve to quantify both time and space and are very efficient number crunchers. Brian Eno made some of his most prominent early explorations into generative music via digital software programs, and he himself has since been responsible for authoring several popular programs for composing generative music. However, since the dawn of the digital age, generative music has come up against two significant barriers that prevent both composers and listeners from fully immersing themselves in the possibilities of the practice. The first of these two barriers is that since generative music must be experienced in the moment of its creation, any recordings of generative music cease to be truly generative. Just like recordings of free improvisation, recordings of generative music, although valuable for archival purposes and study, nullify its aleatoric and stochastic nature. A recording is not generative, and can be played back repeatedly to offer the same sonic sequences again and again. This is fundamentally opposed to the intentions of generative composition. The second major issue that faces generative music in the modern era is the high economic barrier of entry to composing it digitally. Although computers have become increasingly affordable in the twenty-first century, for those of limited means the tools for writing and producing generative music are still high enough to be preventative. There is also an intellectual barrier to generative music. While many softwares that are not purpose built for composing generative music are capable of creating generative systems, they typically require command line computer programming skills that are simply out of reach for the average musician or artist looking to explore the realm of generative music and audio. This economic element of generative music also extends to the first issue facing it, as it is typically required for those listeners interested in experiencing generative music to own specific platforms and software programs for playback.

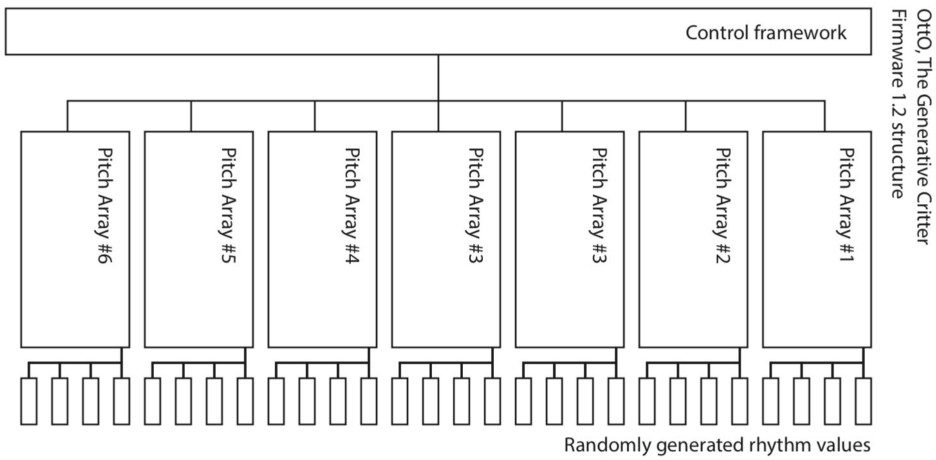
While strides are being made in technological accessibility in more general terms, generative music still remains a niche musical practice and therefore these barriers are unlikely to be specifically addressed by consumer culture at large anytime in the immediate future. That is where *OttO* comes in. *OttO* was conceived as a solution to these two issues facing generative music listeners and composers alike. *OttO* is a completely self-contained hardware device that relies on free, open source tools and affordable electronic components to give users the ability to program generative music and listen to it without spending significant sums of money on high end computers and software packages. Furthermore, *OttO* comes loaded with an evolving generative composition for those that may only be interested in hearing the splendor of generative sound structures in their intended nature.

The initial *OttO* prototype is built around the Arduino microcontroller and its integrated development environment. Building around the Arduino has the advantage of offering a vast community of Arduino users and collective support as well as free software and libraries tested and written by that same community. Arduino boards themselves vary in price, but clone boards from third party manufactures are typically under $20. Furthermore, the Arduino programming language is written and designed to be user friendly and educational, meaning that even those with no computer programming experience will be able to get under the hood of *OttO* and experiment with the firmware and code structure. The audio generation of *OttO* is handled by a simple discrete resistor ladder digital to analog converter that costs no more than a few dollars in components to build. This DAC is 8-bit and programmed to produce basic digital sawtooth tones reminiscent of vintage video game consoles, although other tones are possible as well. Finally, *OttO* comes with a built in speaker, audio line output, and liquid crystal display for users to program text and animations. This all adds up to a strikingly affordable, completely efficient generative platform the likes of which has not previously existed.

Ultimately, while *OttO* is designed with specific uses and functions in mind, the complete documentation itself will be hosted as an open source project to allow artists and composers the flexibility to develop independent versions of *OttO* to fit their own specific needs. If the essence of generative music is to create unpredictable structures through time and space based on a few rules and governed by a system, than going open source is the only viable way to stay true to that spirit, as open source abides many of those same fundamental notions. *OttO* is a critter of the digital music era. Lo-fi and playful, it may come off as unassuming to some. But rest assured, *OttO* is mutable and adaptable and makes good on the promise of big things in a small package.

OttO Technical Specification:

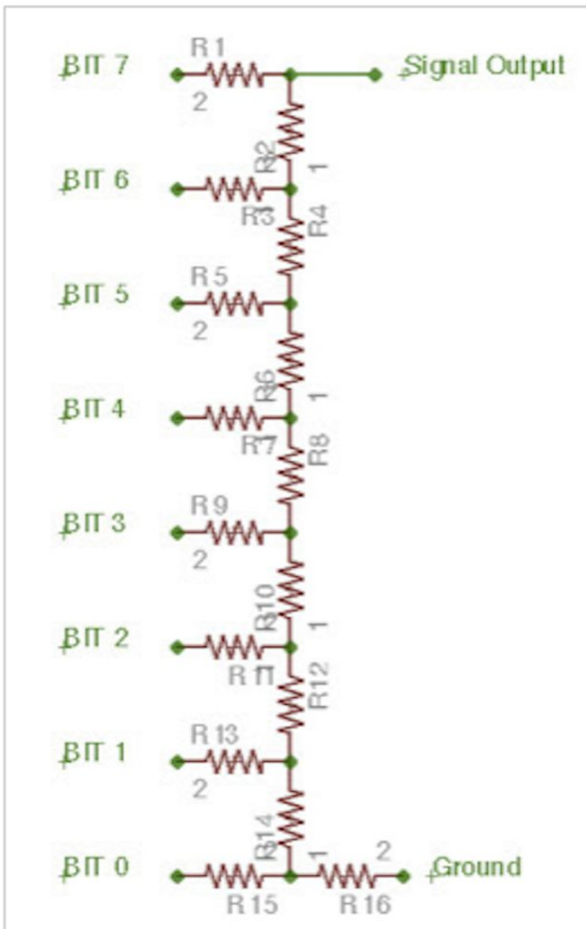
Firmware 1.2:



OttO's primary firmware utilizes the Arduino random() function to create values that determine one of six different pitch arrays to access. The seed value used to set the random function is drawn from the electrostatic value on an analog input pin on the Arduino board, assuring an adequately random starting point for the code each time the device is turned on. These six pitch arrays contain several values that are then used to determine the frequency of the sawtooth output. Upon each cycle of the control framework code that determines pitch array, a random set of four rhythm values are generated to use in the composition. These values are not drawn from an array or table and range from 100 milliseconds to 3 seconds, thus insuring consistently organic and unpredictable rhythmic variations. To download firmware 1.2, visit: www.grantbouvier.com/devices/otto

The R2R ladder:

OttO makes use of a simple but efficient resistor ladder digital to analog converter (DAC). The Arduino Uno (and most other cheap Arduino clone boards) does not contain a DAC natively. Although it is capable of outputting simple square and pulse wave tones via its digital outputs, more complex waveshapes can be produced when using even a simple DAC, such as the R2R.



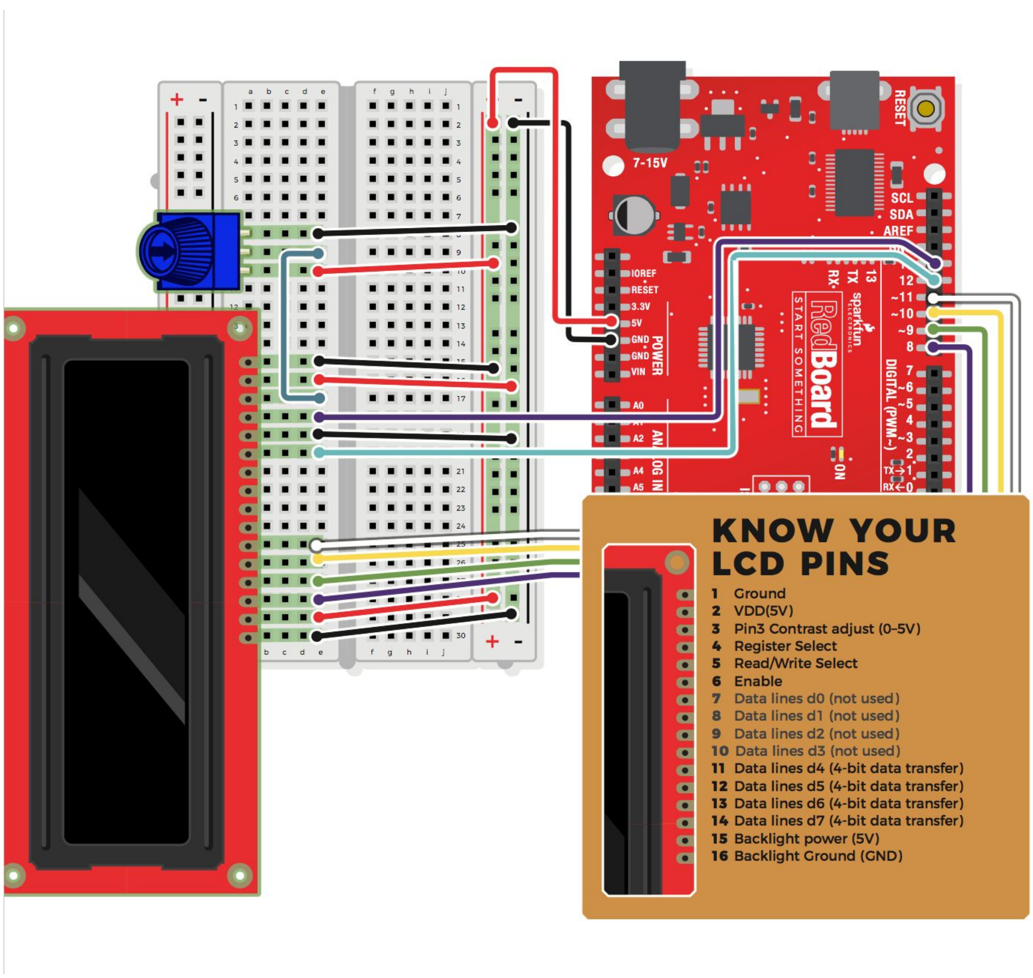
This simple circuit, which is commonly referred to as the ‘R2R ladder”, takes parallel binary data and converts it to analog signal at a specified sample rate. The beauty of the R2R, and where it’s name comes from, is that it requires only two resistor values in its construction. Furthermore, the ladder can be built using a single resistor value if necessary. In *OttO*, a 10k ohm ladder is used and is connect to the Arduino’s digital pins 0-7 following an implementation outlined in Bret Edstrom’s *Arduino for Musicians* (2016), Chapter 9, page 200.

The R2R outputs a voltage based on any 8 bit binary value sent to it. A value of 11111111 (digital pins 0-7 all set high) would constitute a maximum output voltage, while a value of 00000000 (all digital pins set low) would constitute a minimum output voltage. A digital 1 value on any of the Arduino’s digital pins provides a set voltage value, with multiple pins in various 1 or 0 states summing through the resistor ladder to create complex voltages. These various voltage values are then used to ‘draw’ waveshapes and output complex signals. The audio output from the DAC is decidedly lo-fi and reminiscent of vintage video game consoles, but is efficient and capable of producing a variety of waveforms for sound synthesis.

<u>The LCD Screen:</u>

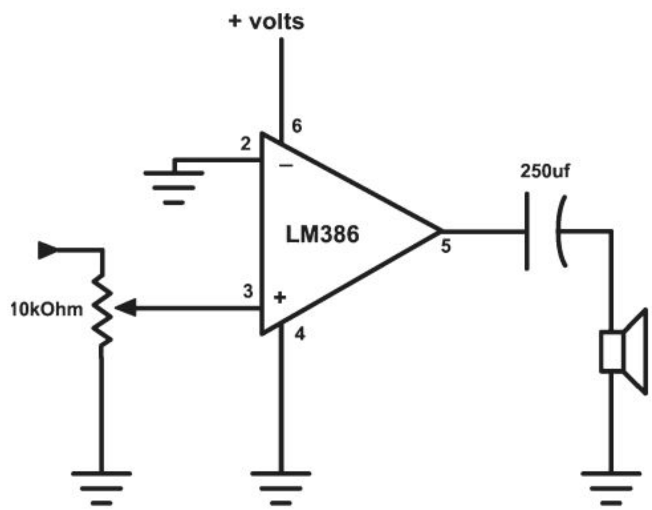
OttO evolved from including a simple LED indicator for debugging and visual feedback to including a fully functional and integrated liquid crystal display. *OttO* makes use of the Arduino LiquidCrystal.h library to interact with the display, which is included in the current firmware (1.2). Physically, the SparkFun Inventor’s Kit Version 4 (Chapter 4, page 73) implementation is used. This implementation uses the Arduino digital pins 8-13 and includes a 10k Ohm trim potentiometer for screen contrast adjustment. At this time, the actual visual information displayed on the display is still in development, to be completed in a later firmware update. While LCD screens are not typically a component an average builder might have on hand, they have become exceedingly cheap, and the compact two line unit used in the prototype can be acquired in a number of styles from various retailers for under $20.00. The cost consideration of the display was not ignored in the design of *OttO*, but the visual possibilities that are allowed by including it have been deemed well worth the price.

Sparkfun Inventor's Kit LCD implementation:



The Amplifier:

OttO features a built in speaker so that a listener needs no additional equipment to enjoy the device and can experience its sounds anywhere. The amplification circuit used in the initial prototype is one featured in Nicolas Collins' *Handmade Electronic Music* (2009), Chapter 27, page 247:

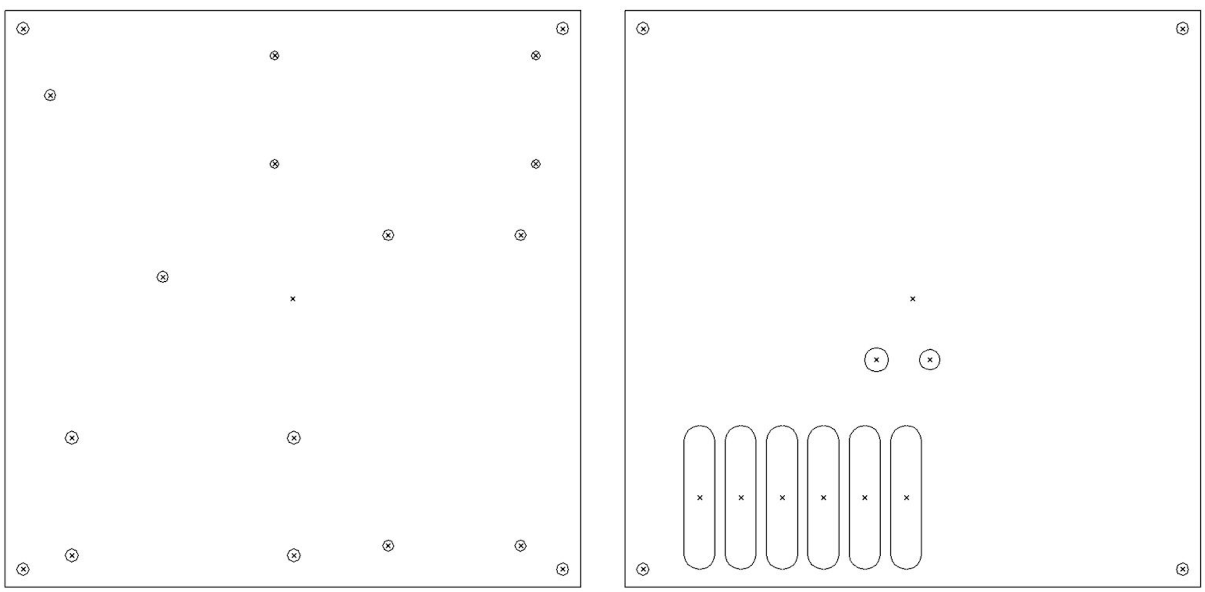


The LM386 is a cheap and widely available integrated circuit that delivers plenty of volume to the speaker in the prototype. The circuit works with most small speakers under 5 watts with a variety of impedance values. This implementation does have a noticeable noise floor however, and an upgrade is in the works for a later prototype that still uses the LM386 but with an improved signal to noise ratio.

The amp circuit is connected directly to the output of the R2R DAC. No loading or buffering issues have been encountered yet, but this matter will be fully tested in a later prototype. Under certain conditions, amplifier circuits can distort signal because of mismatched impedance values between the signal source and the amplifier itself. So far these issues have been avoided with *OttO*, as the LM386 is known for its versatility in terms of loading effects. An additional buffer stage may be desirable, but is not required.

Laser Cut Enclosure:

OttO uses a ‘sandwich’ style laser cut enclosure. The cut includes mounting holes for all essential parts and is clear acrylic so that the display can be clearly seen from any front facing angle. This prototype measures 6.5 x 6.5 inches and used various standoffs for mounting all boards and components. Contact grantbouvier@gmail.com for the original vector files if desired.



The initial prototype enclosure (outline pictured above) is under ongoing redesign for later builds.

For additional documentation, firmware updates, and demos visit:

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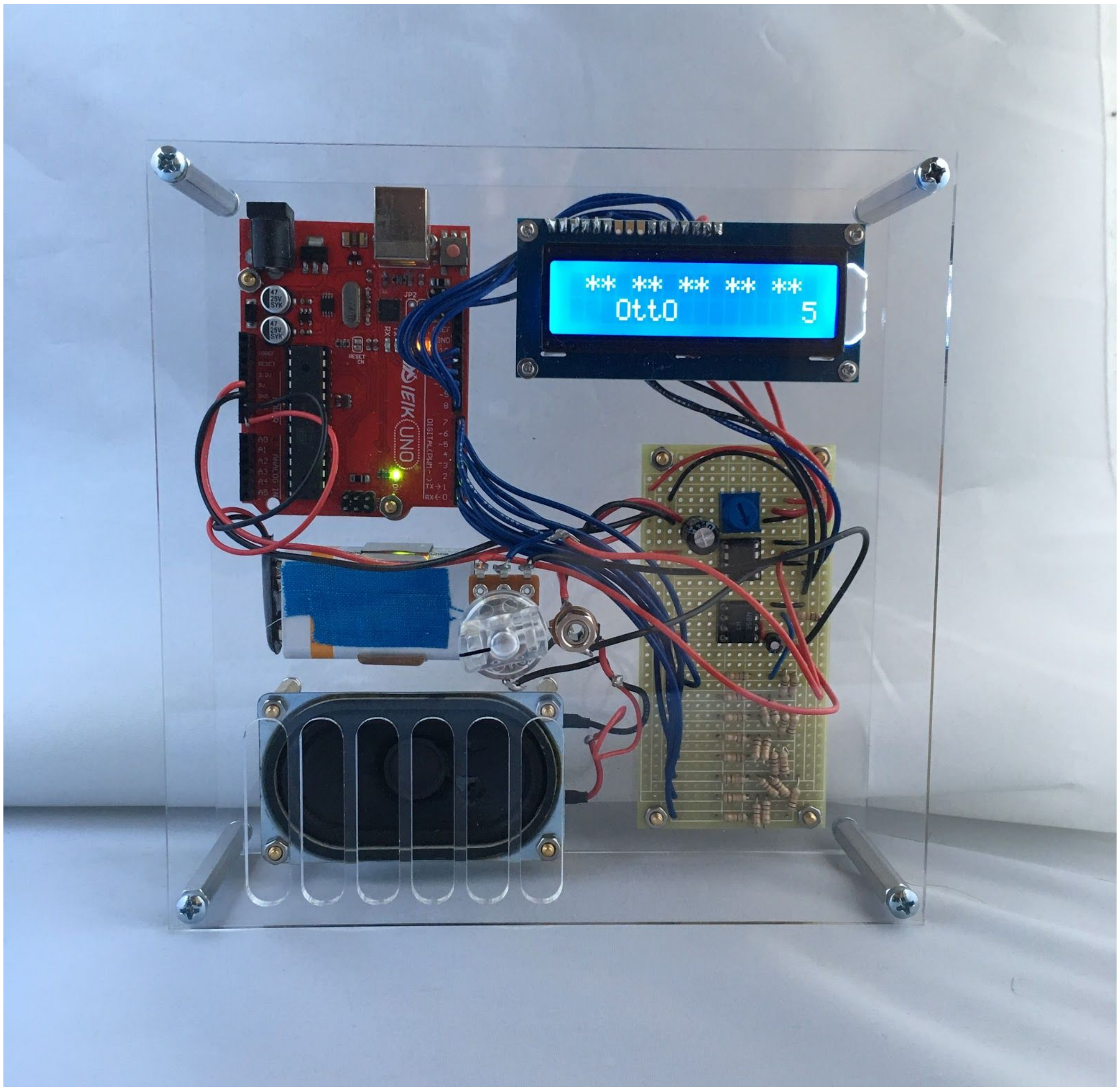
Please direct any questions, concerns, or inquiries to:

grantbouvier@gmail.com



Resource / Work Cited:

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