

UC Riverside

UC Riverside Electronic Theses and Dissertations

Title

Ionic Nylon and Sonitia: Training the Ears of Gamers

Permalink

<https://escholarship.org/uc/item/91b913g2>

Author

Clark, Christiaan Aaron

Publication Date

2018

Peer reviewed|Thesis/dissertation

UNIVERSITY OF CALIFORNIA
RIVERSIDE

Ionic Nylon and Sonitia:
Training the Ears of Gamers

A Thesis submitted in partial satisfaction
of the requirements for the degree of

Master of Arts

in

Music

by

Christiaan Aaron Clark

June 2018

Thesis Committee:

Dr. Timothy Labor, Co-Chairperson

Dr. Paulo C. Chagas, Co-Chairperson

Dr. Ian Dicke

Copyright by
Christiaan Aaron Clark
2018

The Thesis of Christiaan Aaron Clark is approved:

Committee Chairperson

University of California, Riverside

ABSTRACT OF THE THESIS

Ionic Nylon and *Sonitia*:
Training the Ears of Gamers

by

Christiaan Aaron Clark

Master of Arts, Graduate Program in Music
University of California, Riverside, June 2018
Dr. Timothy Labor, Co-Chairperson
Dr. Paulo C. Chagas, Co-Chairperson

In the 2004 dramedy film *Sideways*, a classical guitarist can be heard playing the guitar piece *Recuerdos de la Alhambra* in one of the Santa Ynez Valley wineries. This is a lovely piece of music, but it also unfortunately perpetuates a stereotype that many guitarists have worked hard to avoid. Filmmakers and other popular culture outlets have typecast the classical guitar as an instrument that can only produce harmonious sounds. This thesis is comprised of two different software applications that are designed to break down this stereotype: *Ionic Nylon*, a Virtual Studio Technology (VST) sampler and sample library that allows non-guitarist musicians to use the plentiful sounds of the nylon string guitar using MIDI controllers, and *Sonitia*, the proof-of-concept demonstration of an ear-training puzzle game that uses *Ionic Nylon*'s samples as the primary audio source.

This written portion of the thesis will outline the necessity of these two products as tools for music composition, arrangement, performance and education. Due to the intimidating nature of writing music for the guitar, new textures are rarely seen in the

guitar repertory because guitarist composers tend to be stuck in idiomatic “boxes.” The well-produced samples, thorough feature list and intuitive graphical design of *Ionic Nylon* should help curb many of these intimidations. To reach a wider audience, gamers will play through *Sonitia*, a game that establishes semiotic relationships between geometric shapes and audio qualities of particular samples as rules to solve the puzzles. The game uses a striking narrative to bring music (specifically that of the nylon string guitar) to the forefront of its overall design, hopefully leaving gamers with a new positive emotional relationship between these sounds and fun.

Table of Contents

I. Inception	
A. Survey of Existing Systems.....	1
B. Relationship to Guitar Performance.....	2
C. Guitar Composition Aesthetics.....	3
II. <i>Ionic Nylon</i>	
A. Guitar Sampling.....	5
B. Hart Instruments Sampler Engine.....	6
C. Graphical User Interface.....	9
III. <i>Sonitia</i>	
A. Narrative and Design.....	11
B. Influences.....	12
C. Unreal Engine.....	14
D. Features.....	16
IV. Appendix: Digital Archive.....	21

List of Figures

Figure 1: C++ Coding in HISE	8
Figure 2: The current GUI of <i>Ionic Nylon</i>	9
Figure 3: <i>Sonitia</i> 's main objective.....	12
Figure 4: Raytrace used to detect which objects are being looked at.....	14
Figure 5: Bird's Eye view of <i>Sonitia</i>	15
Figure 6: Alternate view of <i>Sonitia</i>	15
Figure 7: The first level of <i>Sonitia</i>	17

I. Inception

A. Survey of Existing Systems

This thesis project is the amalgamation of four distinct personal passions and skills: guitar performance, music composition, programming and computer gaming. The inception of *Ionic Nylon* (a new sampler and sample library) happened in the early summer of 2017 during a hike in Rancho Cucamonga, CA. A banal conversation morphed into the realization that there is a scarcity of capable nylon string guitar VST samplers that provide a robust and complete set of articulations beyond what sounds “pretty.” A subsequent Google Search proved that the current virtual instruments on the market are lacking many crucial elements.

A sampler is a piece of software that allows composers or performers to trigger pre-recorded audio samples (from a sample library) usually using a MIDI controller or other music hardware. EastWest Sounds and Vienna Symphonic Library create magnificent symphonic orchestra samplers that strive to make the listener sound like they are listening to a live concert when their eyes are closed. Both of these companies have their own nylon string guitar samplers and libraries, but the audio quality and/or amount of features seem like an afterthought compared to their other software. For instance, Vienna Symphonic Library’s *Concert Guitar* sampler has an impressive set of articulations, but the demonstrations provided¹ show a lack of dynamic range (they are highly compressed). This could be because of the myth that the nylon string guitar is

¹ “Concert Guitar,” Vienna Symphonic Library, https://www.vsl.co.at/en/Plucked_Instruments/Concert_Guitar (accessed May 10th, 2018). The decision to use well-known pieces of music such as Roland Dyens’ *Tango en Skai* and Joaquin Rodrigo’s *Concierto de Aranjuez* further demonstrates how the samples lack the necessary dynamic range of the guitar.

quiet, or an improperly calibrated recording session in which soft samples had to be gained.

A sampler with acceptable recorded audio quality and a sophisticated feature list is *Evolution Modern Nylon* from Orange Tree Samples, but a glance through this list shows that it only provides four different individual note articulations: Normal Sustain, Palm Mute (a colloquialism used to refer to what is usually called *pizzicato*), Mute, and Harmonics. The samples were performed with a plectrum which creates an abrasive timbre in comparison to the tone of a well-trained classical guitarist that uses his or her right hand nails. This creates a sound similar to the style of the guitarist duo *Rodrigo Y Gabriela*, but it also severely limits the usability of the sampler in a lighter setting. This search showed that a better solution needed to be made that will satisfy two drastically different needs: above satisfactory recorded samples from a classical guitarist with impeccable tone and a library that provides the full breadth of the nylon string guitar's multitude of timbres.

B. Relationship to Guitar Performance

As a professional guitarist, I was dissatisfied with the music software industry's apparent comprehension of the complexity of an instrument that can sound like so much more than what is currently represented. *Ionic Nylon* is first-and-foremost motivated by a passion for guitar performance and music composition. While studying Guitar Performance at the University of Delaware with Professor Christiaan Taggart, I played pieces that spanned all periods of music. Practically every piece was either composed by

a guitarist, or written for a different instrument and subsequently arranged by a guitarist such as Francisco Tarrega's arrangements of the music of Frédéric Chopin. Classical guitar became more popular among modern and contemporary composers in the 20th century, but the majority of the current standard repertoire still consists of music written by guitarists such as Mauro Giuliani, Fernando Sor, Heitor Villa-Lobos and Agustín Barrios. While this may initially seem fine, this repertoire is riddled with musical textures that tend to repeat themselves such as the same plucking pattern that may exist in different pieces or idiomatic harmonic voicings that are impossible to escape. These are figurative "boxes" that guitarist/composers get stuck inside. A prime example of this exists today called the "rock box," a fret pattern that contains the minor pentatonic scale that every guitarist learns within the first few months of learning electric guitar to use for improvised soloing. The beauty of performing guitar music written by non-guitarists lies in the complexity of new textures that are imagined without the fretboard blinding the creative process.

C. Guitar Composition Aesthetics

In a constant search for gems that could come out of the rough, American guitarist Sharon Isbin has commissioned works² from many leading contemporary composers such as guitar concertos by John Corigliano and Tan Dun (titled *Troubadours* and *Yi2* respectively). Unfortunately, many classical non-guitarist composers that have written for

² vaimusic, "SHARON ISBIN: TROUBADOUR," Filmed [2014], YouTube video, 4:29, Posted [November 13th, 2014], <https://www.youtube.com/watch?v=hIrXFBrrmw>. This video shows John Corigliano and Tan Dun's vulnerability in the context of guitar composition.

the instrument seem to have only written one or two pieces for it. Alberto Ginastera only wrote *Sonata for Guitar, Op. 47* despite being perfectly written for the intricacies of the instrument. Pieces with similar textural complexity like Luciano Berio's *Sequenza XI* cannot be modelled by any nylon string guitar sampler currently on the market. These restrictions stem from the many different sounds that can be produced from the instrument, and how each composer uses them. Right-hand position can change the articulated sound from round and beautiful if plucked over the fretboard (*sul tasto*) to raspy and abrasive if plucked at the bridge (*sul ponticello*)³ and there are also two ways the right-hand can pluck the string. If a player wants the foreground melody to come out a little stronger, he or she uses a rest stroke (a pluck where the finger follows through one string to the next) for that line. Free strokes (a pluck without the follow through) can be used for the rest of the background and middleground voices to differentiate the importance of each line. These are just some of the techniques that cannot be properly emulated by any available software, even though the same attention-to-detail goes into building orchestral sound libraries.

As a composition major at the University of Delaware, my composition professor Dr. Jennifer Margaret Barker allowed me to increase this repertoire. The curiosity continued to increase, however, about why she and other composers seem reluctant to write music for the guitar. She suggested that the general consensus among non-guitarist composers seems to be that the complexity of performing the instrument (such as how the

³ Ginastera, Alberto, *Sonata for Guitar Op. 47*, London, UK: Boosey & Hawkes, 1976. Ginastera requires players to move back and forth between these two different timbres in the third movement (*Canto*).

same note can be played on multiple strings) frequently scares them away from the challenge.

The enigmas of guitar orchestration have impeded the evolution of modern guitar music by the non-guitarist composers who might be able to address them. *Ionic Nylon* should act as an aid for composers. With a 24-fret guitar, a player can play E4 (which usually sounds on the highest open string) on all six different strings. This dense mass of options makes it difficult to decide exactly where a note should be played in a chord. *Ionic Nylon* provides a graphical representation of where notes and chords are played. If these artists cannot audiate⁴ the sound of the instrument the same way they can imagine the sound of an entire orchestra or wind ensemble, the final version of *Ionic Nylon* will have a more comprehensive library of samples than any other in existence, allowing academic and film composers to implement the instrument into their future works so the inimitable sound of the nylon string guitar will never be forgotten.

II. *Ionic Nylon*

A. Guitar Sampling

After analyzing traits existing samplers lack in terms of audio quality and user interaction I started building the sampler and sample library. Before producing anything, the first step of the process was to figure out which articulations and textures were going to be included so that the recording process went as smooth as possible. *Ionic Nylon's*

⁴ The Gordon Institute for Music Learning. "Audiation." GIML: The Gordon Institute for Music Learning. <https://giml.org/mlt/audiation/> (accessed June 11th, 2018). "It [Audiation] takes place when we hear and comprehend music for which the sound is no longer or may never have been present."

folder hierarchy mimics EastWest's *Symphonic Orchestra* and is constructed such that each individual note has its own sound file in a folder dedicated to its discrete articulation. A spreadsheet listed each individual pitch in rows, underneath the following designations in columns: normal, sul tasto, ponticello, harmonics, hammer-ons, pull-offs, pizzicati, Bartok pizzicati, tambour and percussive.

The recording setup included two close Neumann pencil condenser microphones (one pointed directly at the sound hole and one pointed directly at the neck) and one far microphone in the recording space (to eventually provide an option in the software that includes more natural rather than digital reverb). All of the samples were obtained by playing each note four times in ascending chromatic order into one long Apple Logic session for each articulation. Once each final recording was made, the files were examined to find the two best performances of each note and cut each one out with a length of five seconds. Two versions of each note were chosen so that a round robin⁵ effect could take place between two of the same note. A subtle fade out was added to the tail of each sample to get rid of any extraneous noise. The final step of the recording process was to adjust each sample to the same decibel level (-2db for all of *Ionic Nylon*'s samples) so dynamics would be consistent when manipulating velocity on a piece of hardware.

B. Hart Instruments Sampler Engine

⁵ This adds an extra human-like quality to the digital performance of the software by preventing the exact same clip from playing twice in a row if the same note is rearticulated.

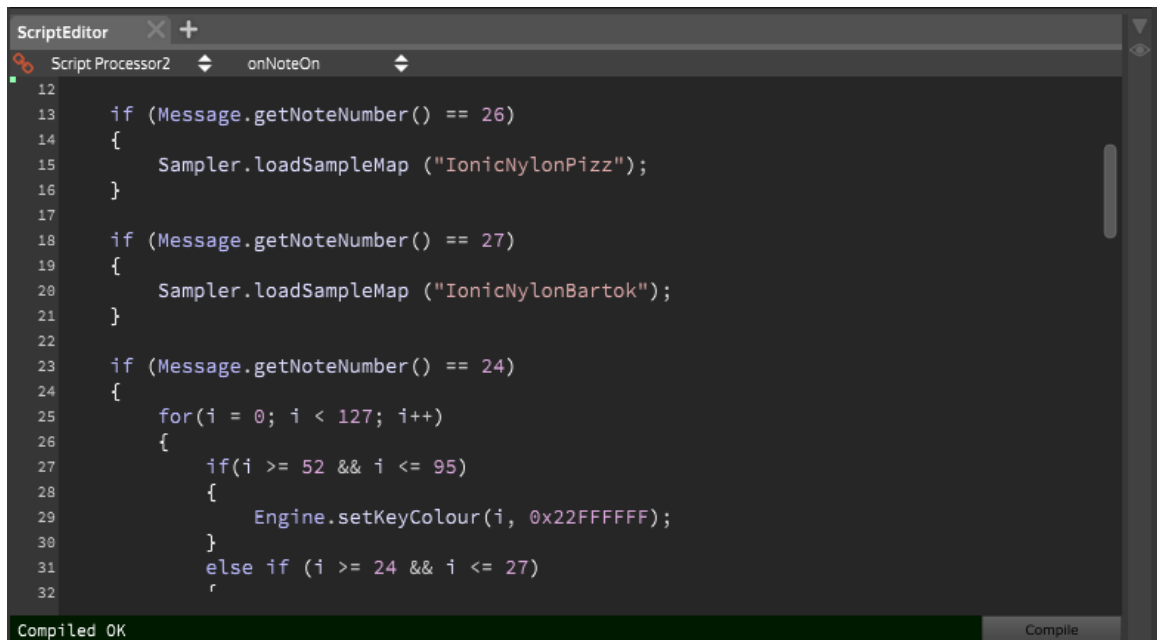
Ionic Nylon was built using Christoph Hart's open source C++ framework for sampler development, Hart Instruments Sampler Engine (HISE)⁶. Hart designed this framework so that anyone with elementary programming and music production skills could build a sampler with many different audio processing tools. HISE would not exist without ROLI's more complex open source framework JUCE though. While much of HISE's functionality thrives on the ability to literally drag-and-drop audio into a player, JUCE still primarily relies on its object-oriented programming.

The "Sample Map" portion of HISE uses a token-parser system that decides which MIDI note a sample will be connected to, the low and high velocity limits of the particular clip (in case a designer wants a note to only come out at lower or higher velocities, such as a rest stroke between 64 and 127 and a free stroke between 0 and 63) and a round robin designation to dictate what order the samples will play in. After saving each individual sample from the recordings as their proper token-parsing names, the files were dragged-and-dropped onto a new Sample Map for each of the separate articulations.

This is only the first step in the process of creating a dynamically-rich sampler in HISE however. Once the samples are parsed, all of the notes can then be played on a MIDI keyboard, but they will always play at the same volume no matter how hard or soft a key is pressed down. To fix this, a *Velocity Modulator* was added in the "Gain Modulation" section of the program. A table can be drawn to map how the overall gain of the samples should respond to incoming MIDI velocity. The most realistic sound for *Ionic Nylon* came from a logarithmic rather than a linear table, since players almost never

⁶ Hart, Christophe, "HISE," GitHub, <https://github.com/christophhart/HISE> (accessed February 25th, 2018). Christophe Hart is always updating the program, so it is best to grab the code from GitHub.

play light enough for velocities between 0 and the 30s. The attack, decay, sustain and release (ADSR) can also be influenced in the “Gain Modulation” section, and the final Graphical User Interface (GUI) allows users to alter the program’s preset if they want to detract from the human element and create computer music. Many post-processing effects can be added in HISE, but this software only features limited reverb functionality since most composers and producers add these effects in their DAW of choice anyways.



```
ScriptEditor
Script Processor2 onNoteOn
12
13 if (Message.getNoteNumber() == 26)
14 {
15     Sampler.loadSampleMap ("IonicNylonPizz");
16 }
17
18 if (Message.getNoteNumber() == 27)
19 {
20     Sampler.loadSampleMap ("IonicNylonBartok");
21 }
22
23 if (Message.getNoteNumber() == 24)
24 {
25     for(i = 0; i < 127; i++)
26     {
27         if(i >= 52 && i <= 95)
28         {
29             Engine.setKeyColour(i, 0x22FFFFFF);
30         }
31         else if (i >= 24 && i <= 27)
32         {
33             r
34         }
35     }
36 }
Compiled OK
```

Figure 1: C++ Coding in HISE

Certain aspects of the sampler required more complex coding. The figure above shows some of the object-oriented functions used to load certain features. The keyswitch function of *Ionic Nylon* that allows composers and performers to easily switch between different articulations was coded by loading the respective sample maps whenever one of the lower MIDI notes (pitches between 24 and 27) is pressed on either the controller or keyboard in the GUI. The coding also perfected many elements of the GUI as well. The

bottom of Figure 1 shows one example of how the built-in keyboard's colors are altered to show different functions. MIDI notes that have no mapped samples are colored gray, those that do are white and the four keyswitches are blue. Calls also had to be made to connect the aforementioned envelope and reverb units to graphical knobs so that users can easily adjust specific attributes and dial in their desired tone.

C. Features

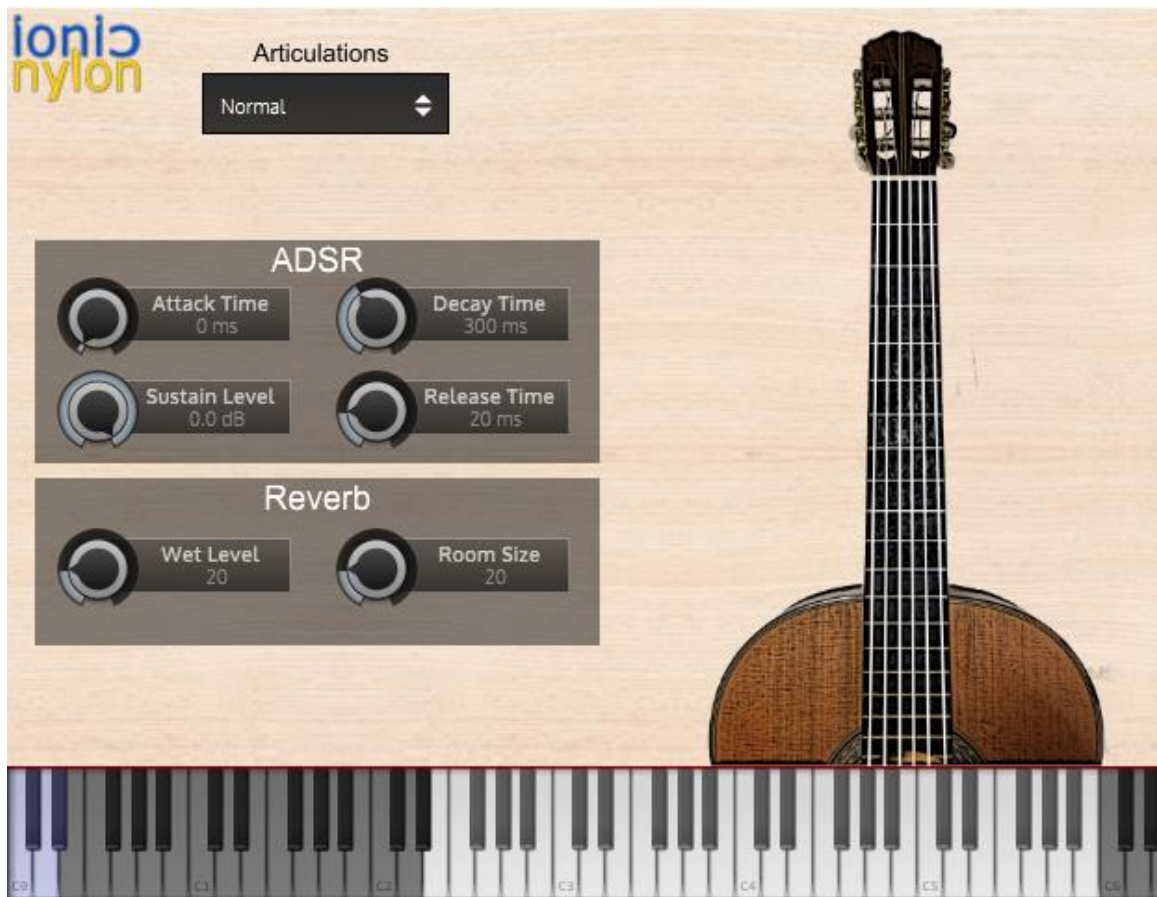


Figure 2: The current GUI of *Ionic Nylon*

The image above shows many of the current features of *Ionic Nylon*. At the very bottom of the GUI there is a six-octave keyboard that allows the composer to click on

individual notes if there is no MIDI controller plugged into the computer. The Articulations menu to the right of the logo provides an alternative method to switch between articulations in case composers are using hardware with limited octave ranges. When any notes are played on the keyboard or with a MIDI controller, red dots appear on the fretboard to show the composer where a particular note is most easily played. As mentioned previously, users have the ability to manipulate the output of their guitar sound by altering the ADSR and reverb attributes with the given dials. While it is not shown in the above figure, the software can also detect and make a list of any MIDI controllers that are plugged into the computer if composers are using it as a standalone application.

More features will be added over time to outshine the other nylon string guitar samplers on the market. The eventual inclusion of both rest and free strokes samples will make this the only library that can truly mimic the dynamics of a classical guitarist. The sampler will determine which musical lines to bring out so that foreground textures are “played” with rest stroke samples while background textures use the free stroke samples.

An arpeggiator will be added into the software that focuses on potential right-hand plucking patterns and will act as another educational tool for composers. Even though arpeggiation is a pivotal aspect of the majority of repertoire for classical guitar, none of the previously mentioned samplers have this function either. Instead of the usual 16 or 32 note grids that exist with most MIDI arpeggiators, a graphical element will be introduced that relates arpeggiated chords to the right-hand plucking pattern that would be used by a real player (showing p for “pulgar” or thumb, i for “indice” or index, m for

“medio” or middle and *a* for “anular” or ring). There will also be a chord strumming section of the program that allows composers to emulate this sound with properly voice-lead chords as well as the flamenco strumming technique known as rasqueado. This is simply the first in what will be a massive sample library of different plucked string instruments (such as electric guitar and mandolin) which will all use similar GUIs and contain more of these similar features.

III. Sonitia

A. Narrative and Design

Putting *Ionic Nylon* together was just like putting a puzzle together. There were individual pieces (the samples) and a specific order in which to connect them (the C++ coding). A second premonition occurred while creating the software that these samples could and should be used in a musical video game. Video games allow people to be something they are not. I am a musician in real-life, and yet games have allowed me to be anything from a wizard to a computer hacker without any of the training. If this is possible, then how could games allow a real-life computer hacker to be a musician without all of the training? The answer lies in temporary music that student UCR composers have written for *Ionic Nylon*'s companion game, *Sonitia*.

Sonitia is a puzzle game that strives to slowly and slyly teach its players how to play and hear music in a newly devised notational system based on differently-sided polygons. Gamers will solve puzzles based on musical concepts such as transcription, arrangement and composition. The narrative of the game centers on a player-controlled

archaeologist that is trying to find the legendary Golden Guitar inside of an extinct musical society's recently discovered hidden catacomb. The society devised the tomb so that only the greatest musician alive would find the artifact behind their traps and increasingly difficult ear-training puzzles. The amount of sides on polygonal buttons distinguishes between different pitch classes (more sides means a higher pitch). More polygons are added to each button to differentiate between separate articulations and timbres (an extra smaller triangle on a button means that the sound represents pizzicato). The game therefore seeks to activate synesthesia hidden inside the gamers with the connection between sight and sound.



Figure 3: *Sonitia*'s main objective

B. Influences

Sonitia has three main influences that shaped the technical and artistic aesthetics of the game: Thekla, Inc.'s *The Witness*, Croteam's *The Talos Principle* and Valve's game series *Portal*. *The Witness*' lead game designer Jonathan Blow created a marvel where players learn how to play the game simply by playing the game and learning from carefully designed trial-and-error. Every puzzle in the game uses the basic game

mechanic of guiding a finger through panels of mazes. Different rules are established in various areas of the world through the use of shapes that are found within the maze, forcing the player to navigate his or her finger either towards or away from a certain direction.

The Talos Principle influenced the in-game environment and the rewards received in each puzzle. While the surrounding world is a complex combination of nature and unique architecture, the main purpose of the game is to simply collect Tetris-shaped objects that acts as keys to open doors and move further in the game. Each of *Sonitia*'s main areas will expand on the in-game morphology and force players to collect golden strings that act as keys and that will eventually be placed on the Golden Guitar in order to complete the main story.

Eventually, *Sonitia* will contain voiceover (V/O) with an actor that plays the archaeologist searching through the tomb. This draws inspiration from GLaDOS, the main antagonist from Valve's *Portal* franchise. Despite being the antagonist, she frequently provides tips to the players when a particular puzzle is taking an abnormally long amount of time to complete. Help will be given to the player in *Sonitia* through the archaeologist's internal monologue to enhance immersion in the game and assist struggling players. This dialogue will also be used to enhance character development and build a relatable protagonist such as Square Enix's reinterpretation of Lara Croft in their *Tomb Raider* series reboot.

C. Unreal Engine

Sonitia is developed in Unreal Engine 4 (UE4), a game authoring engine created by Epic Games. Similar to HISE, Unreal Engine's simplistic layout is designed to make game development easier for beginners and even seasoned veterans. The majority of coding in UE4 is handled inside blueprints which use visual programming⁷. Visual programming has predetermined functions with inlets and outlets that are connected with logical flow to output the specific order in which actions should occur. Unreal Engine also allows highly-experienced computer programmers to create their own functions that can be placed into the blueprints of their project. Figure 4 below shows an example of the logic in *Sonitia*'s main level blueprint.

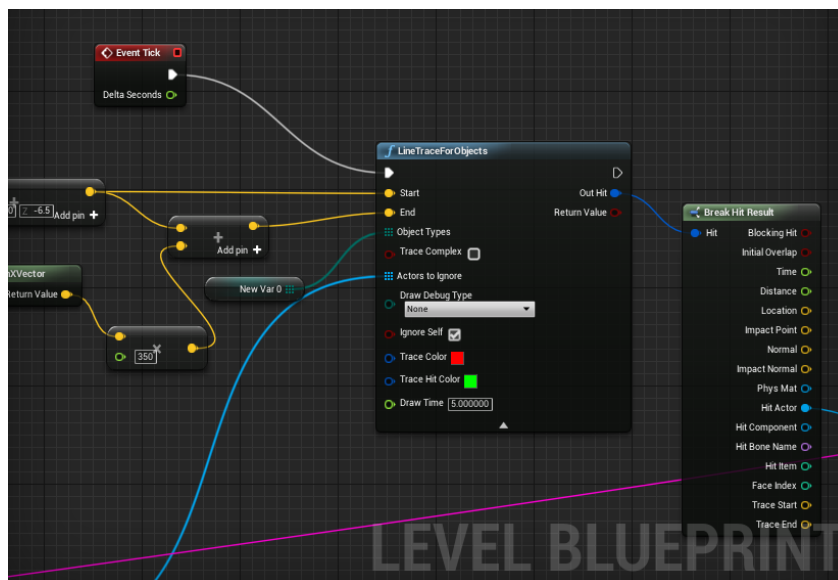


Figure 4: Raytrace used to detect which objects are being looked at

Architects and animators also use Unreal Engine because of its intuitive system for creating 3D environments. The program comes with stock starter content containing

⁷ This visual programming layout will look extremely familiar to any computer musicians that use Miller S. Puckette's program *Max/MSP*.

props that can be dragged-and-dropped into the space and materials that are used to alter them. Props are completely white geometric shapes that can be moved around, rotated and scaled around the X-Y-Z axis. Designers can then place materials onto these objects. Materials allow props to look like naturally-finished wood, shiny stainless steel, and even transparent glass.

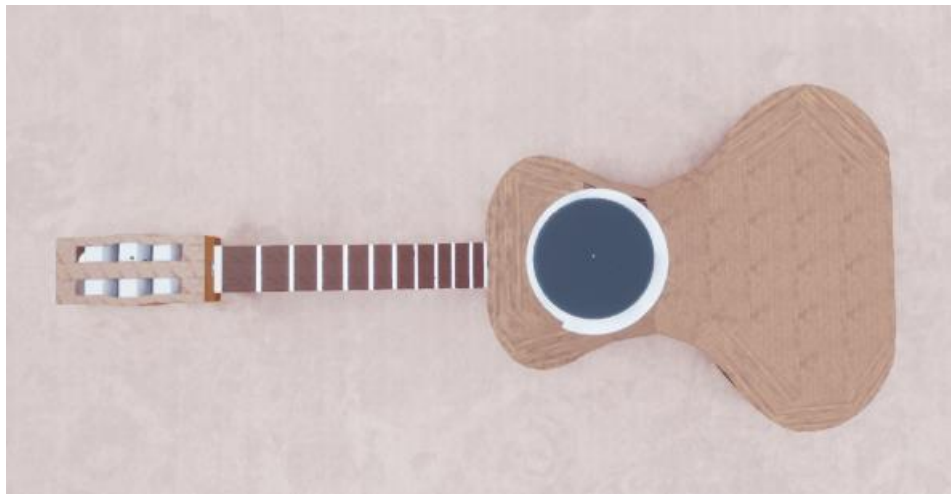


Figure 5: Bird's Eye view of *Sonitia*

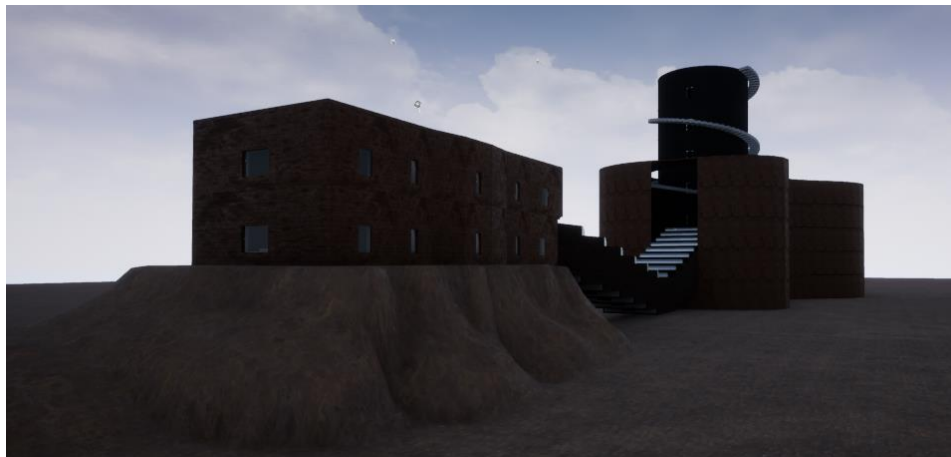


Figure 6: Alternate view of *Sonitia*

Epic Games provides templates with pre-engineered mechanics for the gaming world's most common genres. *Sonitia* was created with Unreal Engine's built-in First

Person Shooter (FPS) template so that mechanics such as the ability to walk, the camera (how the player sees things) and life-like gravity are already coded. Since the template only comes with a standard room that consists solely of cubes, it is up to the designer to act as a virtual deity and create the entire world from scratch. *Sonitia* is built to completely resemble the architecture of a standard classical guitar. Figure 5 shows a birds-eye view of the entire world map, designed to look exactly like a guitar from this particular angle while Figure 6 shows *Sonitia* from the player's position. The final realization of the world's construction can only be seen after reaching the top of the tower where the guitar's sound hole would be.

D. Features

The game's puzzle rooms exist inside this giant imaginary guitar. The player starts inside of a building where the headstock would be, and there are six rooms on each of the two levels of the structure to represent the six tuning pegs on a guitar. This acts as the tutorial area of the game and consists of the simplest puzzles that allow players to figure out how to play the game without any direction. After making it through the tutorial area, players are forced to linearly struggle through more complex puzzles in a linear row of rooms that mimic the design of the guitar neck and its frets. After completing *Sonitia*'s linear introduction, players arrive inside the body of the guitar where the bulk of the game will take place. The elaborate design of these areas has not yet been completed, but will eventually include four differently themed locations: Playful, Beautiful, Quirky and Dark. The first three areas will exist solely inside three

different sections of the body of the guitar. The final Dark area will emulate the sound hole and its rosette, despite being a tower and its spiral staircase in the game.



Figure 7: The first level of *Sonitia*

Just like any puzzle adventure game, the puzzles will start out simple and increase in difficulty as the game progresses. The first puzzle, pictured above, plays the pitches E4 and C#4 (sounding in that order) in the same articulation with a square button and a triangle button placed on the wall. The player will then click the square button to show the higher pitch and then the triangle button to represent the descending pitch. Similar to how Jonathan Blow used trial-and-error in *The Witness* to teach players how to solve the puzzles, the placement of only two button options allows players to discover a clue to the relationship between shapes and pitch. If the player incorrectly clicks the triangle first, an unpleasantly dissonant musical cue is played to show that the wrong button was pressed. When the buttons are pressed in the correct order, a heavenly musical cue is played and doors and gates blocking the way to more puzzles and the Golden Guitar are opened.

The following melodic passage is an example of a much more complicated puzzle that could exist later in the game: F4 played with the pizzicato articulation, C5 played

with the Bartok pizzicato articulation and B4 played normally. To solve this puzzle, players will have to click the corresponding buttons in musical order on the puzzle board to match the right pitch class shape and the correct nature articulation symbol. The puzzles for this thesis' demonstration are motives that are pulled from temporary music that UCR undergraduate composers have written for classical guitar.

The game is currently only a proof-of-concept demo, so there are admittedly some holes that need to be filled. It is anticipated that playing through this game will build gamers' ears, but it is a game first and is primarily focused on being fun for everyone. The game can currently only be played on a computer, so functionality must be built for more platforms, especially mobile devices such as the iPad. The target audience for this game is casual gamers instead of hardcore gamers, so releasing the game on the Apple App Store or Google Play Store should generate more downloads. The only puzzle type that has been designed thus far is dubbed the "transcription" puzzle, as if players are writing down exactly what they hear. There will be other types of puzzles developed with the same geometric morphology based on other music creation concepts such as "performance" puzzles (that will act like rhythm games), and "composition" puzzles (that allow more creative solutions for the puzzle, as long as certain criteria are followed).

Admittedly, certain players will be much better at the game than others, but that should not diminish the fun for anyone that is struggling. Tips will be given here and there through the player's inner monologue, and after a long enough time shapes will light up to show what to click next. While this helps keep the game accessible to some, a specific game mode must be created for the deaf and others with needs so that anyone can

jump into the game no matter who they are. This belief shows another way that *The Witness* has inspired *Sonitia*. While Jonathan Blow's design choices are impeccable, *The Witness* actually comes with a vast amount of accessibility problems. Many of the game's puzzle rules rely on differently colored shapes, rather than different shapes. If the game used different shapes instead of different colors, someone with color blindness, no matter how severe, would still be able to play through the puzzles⁸.

Players become musicians as they distinguish between intricate musical characteristics that are frequently taught in college level music ear training courses but without the necessity of written theory. This interdisciplinary venture shows how music and computer gaming not only intersect, but blend into one concept that encourages traditional composers to write higher quality guitar music with more facility. These separate missions also aim to prevent typecasting of the nylon string guitar as an instrument that can only sound "pretty."

⁸ Board games such as *Ticket to Ride* and *Splendor* have won awards for using this exact strategy and remembering to stay as inclusive as possible for the player base.

Bibliography

- Berio, Luciano. *Sequenza XI*. Vienna, Austria: Universal Edition, 1988.
- Concert Guitar*. Windows. Vienna Symphonic Library.
- “Concert Guitar.” Vienna Symphonic Library. https://www.vsl.co.at/en/Plucked_Instruments/Concert_Guitar (accessed May 10th, 2018).
- Corigliano, John. *Troubadours (Variations for Guitar and Chamber Orchestra)*. New York City, NY: G. Schirmer, 1993.
- Croteam, *The Talos Principle*. 2014; Zagreb, Croatia: PS4, 2016. Video game.
- Evolution Modern Nylon*. Windows. Orange Tree Samples, 2017.
- Ginastera, Alberto. *Sonata for Guitar Op. 47*. London, UK: Boosey & Hawkes, 1976.
- Hart, Christophe. “HISE.” GitHub. <https://github.com/christophhart/HISE> (accessed February 25th, 2018).
- HISE*. Windows. Christophe Hart, 2018.
- HISE*. macOS. Christophe Hart, 2018.
- Sideways*. Digital. Directed by Alexander Payne. Century City, Los Angeles: Fox Searchlight Pictures, 2004.
- Symphonic Orchestra*. Windows. EastWest Sounds, 2008.
- Thekla Inc., *The Witness*. 2016; Stockholm, Sweden: PS4, 2016. Video game.
- Unreal Engine 4.19*. Windows. Epic Games, 2018.
- vaimusic. “SHARON ISBIN: TROUBADOUR.” Filmed [2014]. YouTube video, 4:29. Posted [November 13th, 2014]. <https://www.youtube.com/watch?v=hIrXFBrrwmw>.
- Valve, *Portal*. 2007; Bellevue, Washington: Xbox 360, 2010. Video game.
- Valve, *Portal 2*. 2011; Bellevue, Washington: Xbox 360, 2010. Video game.

Appendix

Digital Archive

1. Executable file of *Ionic Nylon* 0.8 using HISE 1.5.0
2. Sample Library of *Ionic Nylon*
3. Demonstration Video of *Ionic Nylon* (03:36)
4. Unreal Engine 4.18.3 source files
5. Unreal Engine PC Windows 10 (64-bit) executable
6. Gameplay videos of *Sonitia*
 - a. Player's Perspective (05:47)
 - b. Unreal Engine 4.18.3 desktop (00:59)