

Berklee College of Music

Juke:

An Audiovisual Universe

Submitted in Partial Fulfillment of the Degree of Master of Music in Music Production,
Technology, and Innovation

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July 2021

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Abstract

This project presents a new interactive audiovisual game with applications in entertainment, music creation, and education. In the game, dubbed *Juke*, a gamer and musician team up to guide an animated character to the end of a song without falling. Unity, p5.js, JavaScript, and Python scripts are used to create the game, and original musical compositions are incorporated to engage the users. Unity provides a more comprehensive and versatile framework to run the game, while P5.js allows for quick prototyping and development of visual ideas. P5.js ultimately served as the platform for the game demo in this project. *Juke*'s vision is four-fold: (1) to inspire others to engage with audio and music on a deeper level; (2) to provide a new way to co-create music in real time; (3) to foster connection between musicians and gamers; and (4) to make learning and practicing an instrument more social and fun.

Keywords: technological application, Unity, p5.js, music education, video game music

1. Introduction

The idea for this culminating experience (CE) came about through considering various successful music games of the past two decades, and through considering creative and artistic games that do not fit neatly into common genres. In the past, when executed successfully, these games have been met with widespread acclaim and interest¹. The aim of the project is to create a simple and elegant prototype for an immersive audiovisual game engine, that can later be expanded into a full game, with additional levels and musical styles. Through the project, the author seeks to deepen his knowledge about game programming and design (namely through the Unity game engine), audio in interactive media, and audiovisual installations.

2. Review of the State of the Art

This project draws inspiration from various music games over the past twenty years, including *Real-Sound: Kaze no Regret*², *Guitar Hero*³, *Rock Band*⁴, *Dance Dance Revolution*⁵, the *Bit.Trip*⁶ series, and *Dyad*⁷. Each of these games used audio in new and creative ways to

1. Smithsonian American Art Museum, "The Art of Video Games," *Smithsonian American Art Museum and Renwick Gallery*, accessed December 15, 2020, <https://americanart.si.edu/exhibitions/games>; Luke Plunkett, "Time To Start Worrying About Rock Band Availability," *Kotaku*, November 1, 2007, <https://web.archive.org/web/20081216125617/http://kotaku.com/gaming/rock-band/time-to-start-worrying-about-rock-band-availability-318040.php>.

2. Warp. *Real-Sound: Kaze no Regret*. Sega. Sega Saturn. 1997.

3. Harmonix. *Guitar Hero*. RedOctane. PlayStation 2. 2005.

4. Harmonix. *Rock Band*. MTV Games. Xbox 360/PlayStation 3. 2007.

5. Konami, Bemani. *Dance Dance Revolution*. Konami. Arcade/PlayStation. 1998.

6. Gaijin Games. *Bit.Trip*. Aksys Games. Wii/3DS. 2009.

7. Right Square Bracket Left Square Bracket. *Dyad*. Right Square Bracket Left Square Bracket. PlayStation 3. 2012.

engage the user, whether through developing pure-audio worlds, making use of custom interactive controllers, employing aleatoric elements (aspects of randomness in the music), or repurposing game elements for synthetic audio applications. Separately, this project draws inspiration from non-music-centric independent games, namely *Super Mario Bros.*⁸ for its intuitive and simple gameplay, *Flower*⁹ for its aesthetic appeal, and *The Witness*¹⁰ for its simplicity, elegance, and ability to immerse the player in the game environment.

The game developed through this CE draws on gamified elements in the aforementioned references. In particular, it takes inspiration from the simplistic platforming gameplay present in *Super Mario Bros.*, a level selection screen similar to *Rock Band* and *Dance Dance Revolution*, and an aesthetic similar to that of *Flower*. Being primarily an audio game (even more than a video game), it employs audio both for traditional purposes (cues for rewarding certain actions¹¹, engaging background music, reacting to physics in-game) and creative applications. The idea for sound effects in the game are inspired by mods such as *Quilted Thought Organ* for the game *Half-Life*¹², which generate synthesized sounds by interacting with various game objects, as well as *PANORAMICAL*¹³, which allows the player to adjust audio parameters to influence the environment. In this case, the player changes shape and sound when interacting with various objects in the level, and when adjusting audio parameters on the fly. Moreover, it heeds Collins's

8. Nintendo. *Super Mario Bros.* Nintendo. Nintendo Entertainment System. 1985.

9. Thatgamecompany. *Flower*. Sony Computer Entertainment. PlayStation 3. 2009.

10. Thekla, Inc. *The Witness*. Thekla, Inc. PlayStation 4/Xbox One/Microsoft Windows/Nvidia Shield/macOS/iOS. 2016.

11. K. J. Donnelly, William Gibbons, and Neil Lerner. *Music In Video Games: Studying Play* (New York: Routledge, 2014), 82.

12. Karen Collins. *Playing with Sound: A Theory of Interacting with Sound and Music in Video Games* (Cambridge, Massachusetts: The MIT Press, 2013), 117.

13. Fernando Ramallo and David Kanaga. *PANORAMICAL*. Finji. PC and Mac. 2015.

advice¹⁴ to strike a balance between repetitiveness and randomness, to balance consistent cues with an organic feel.

Prototyping and game design make use of the framework created by Donnelly, Gibbons, and Lerner¹⁵ regarding abstract game features in games like *Guitar Hero*: an ideal musical object, a visual representation of this object, a means of interacting with this visual representation, and a means of communicating success or failure in realizing the ideal musical object. In this case, the ideal musical object is a fully layered musical track to go with the theme of the level, the visual representation is the player's character, the means of interacting is through the game controller to interact with other objects in the game environment, and the means of communicating success or failure is through audio cues (stopping the music) and short colored and less color saturation in the player and environment. Generative animated visuals are inspired by the works in *Generative Gestaltung*¹⁶.

3. Description

Juke is an audiovisual game with applications in entertainment, music content creation, and education. The game runs in the web browser and features a catalog of songs composed by students in Berklee's Music Production, Technology, and Innovation master's program. In each level, the goal is to traverse the player across a series of musically mapped platforms to reach end of the song, falling as few times as possible.

14. Collins, *Playing with Sound*, 33.

15. Donnelly, Gibbons, and Lerner, *Music In Video Games*, 79.

16. Benedikt Groß *et al.* "Generative Design," *Generative Gestaltung*, accessed June 13, 2021, <http://www.generative-gestaltung.de/2/>.

In single-player mode, the platforms are automatically generated in accordance with the music. If a MIDI melody file is available, the platforms will reflect the MIDI notes, with higher notes corresponding to platforms at a higher position on the screen. If no MIDI file is available, the platforms will spawn according to the centroid frequency of the sound file on each beat, with higher average frequency content corresponding to platforms at a higher position on the screen.

In multiplayer mode, a gamer and musician team up to traverse the level, and the musician is responsible for generating the platforms by playing accompanying music on a MIDI instrument. The musician can select a controller, instrument sound, and scale mapping.

In both game modes, the gamer is responsible for controlling the player character and adjusting various audio parameters, such as volume and sound speed, to bring about changes in the player and game world. Adjusting volume alters the player's size, and adjusting sound speed alters the player's and the platforms' speed. Additionally, algorithmically generated animated backgrounds sweep across the screen during each level, and entering these backgrounds triggers further changes in the audio parameters. Some backgrounds affect volume and speed, which bring about the same changes described above, while other backgrounds affect reverb, which in turn alters the force of gravity in the game world.

4. Innovative Aspects

Juke is innovative in its combining of various game genres in a new way, giving rise to a “video game cocktail” that is greater than the sum of its parts. First, for its gameplay, it draws upon the simple, fun, and intuitive gameplay of *Super Mario Bros.* to keep the game accessible and easy to digest. Second, for its means of player interaction, it takes inspiration from the innovative interactive musical experiences of the 2000s, namely *Guitar*

Hero and *Rock Band*. In doing so, *Juke* hopes to inspire gamers to engage with music, whether through connecting with friends or learning an instrument of their own. The multiplayer mode that uses real MIDI input is also innovative and robust, as it allows musicians and non-musicians alike to interact with the game in whatever manner is most suitable for them. Last, aesthetically, *Juke* incorporates minimal, colorful, and emotion-driven visuals that are reminiscent of indie games like *Flower*. This way, the visuals and audio fully immerse the player in the game world and leave them eager to discover the beautiful animations lurking around the next corner.

5. New Skills Acquired

Through this CE, many new skills have been acquired. On the technical side: Unity; programming in C#, JavaScript, and p5.js; FMOD for adaptive audio; Ableton Live for audio recording and editing; Adobe Animate and Procreate for drawing and animating digital assets; and Premier and Open Broadcaster Software for professional video editing and screen recording. These technologies offer a broad toolset for any career in game development, programming, and content creation. Other skills developed during this project include game design, networking, collaborating with others, and time management, all of which will be invaluable in any future job that requires organizational abilities and the ability to work on a team.

6. Challenges, both expected & unanticipated

This CE also poses several challenges. To start, learning a wide array of new skills in short time frame and having to start over from scratch halfway through the project requires discipline and a willingness to let go and adapt to meet the needs of the project. Initially, the game was being built in Unity, which requires learning a wide array of content creation software.

The first month was spent learning these various technologies, such as Adobe Animate and FMOD, but without a full development team to split up the work of creating visual and musical assets, programming, designing the UI, and integrating the game components, prototyping became too time-consuming to finish the project in the desired time frame. For this reason, p5.js is used to manage all the game elements in JavaScript code and make prototyping simpler and more efficient.

Designing the game is also more challenging than expected, as is it difficult to anticipate how ideas will be perceived by a wider audience, and to translate abstract concepts into concrete elements in the game. Screen-recording gameplay visuals and audio in high-quality is also technically difficult, requiring Open Broadcaster Software, BlackHole for audio routing between apps, and a sufficiently powerful computer. Other ongoing technical challenges include long loading times; glitches in resuming MIDI playback when using an open-source MIDI JavaScript library¹⁷, achieving complex audio effects in real time in the browser using JavaScript; recording and storing animation frames and audio to save creative in-game compositions, without sacrificing game performance; and latency and synchronization challenges associated with online multiplayer gameplay.

7. Future Ramifications

The future ramifications of this CE are numerous and broad in scope. To start, by making *Juke* both online and mobile-friendly, it can be much more accessible, allowing gamers to connect with musicians from their mobile devices, while musicians create music from a desktop

17. Michael Deal. "MIDI.js," Github, accessed June 13, 2021, <https://github.com/mudcube/MIDI.js>.

application with MIDI support. Projects like p5live¹⁸ will serve as inspiration for building the architecture to support online gameplay.

Next, working with a graphic designer to create a core game aesthetic can make the game more cohesive and engaging. Consulting with a Chilean graphic designer is currently underway. The minimalist, colorful aesthetic can be maintained, and additional inspiration can be taken from the art and architecture of New Orleans, where the term “juke” originated.

In the future, the game can feature two modes: a “Karaoke Mode,” where users can stream or play along with songs in a licensed catalog or even songs that they upload, and a Live Mode where users co-create music and visuals in real time, and where players can jump in and out of sessions asynchronously. The game currently features over one hundred instrument sounds using an open-source Soundfont library¹⁹, as well as the ability to constrain MIDI playback to one of over sixty scales (inspired by the Color Piano web application²⁰), but in the future the game can feature an even greater number of adjustable audio parameters, closer to a full digital audio workstation, as well as more variety in the audio-reactive animations.

From an educational application standpoint, the game can include gamified lessons to help learn any MIDI instrument of choice, offering visual cues and real-time feedback to indicate to the player if their part is being played correctly. Further expanding on the use of color and visual cues to reflect the underlying music theory could also help users to gain a deeper understanding of the underlying audio and music. Players could be motivated to continue

18. Ted Davis. “p5live,” teddavis.org, accessed June 13, 2021, <https://teddavis.org/p5live/>.

19. Benjamin Gleitzman. “MIDI.js Soundfonts,” Github, accessed June 13, 2021, <https://github.com/gleitz/midi-js-soundfonts>.

20. Michael Deal. “Color Piano—Learn to play songs on the piano,” Galactic.ink, accessed June 13, 2021, <https://galacticmilk.com/piano>.

learning and improving through the addition of unlockable content like visual costumes (“skins”), exclusive instrument sounds, and sample packs created by the contributing artists.

Finally, in the future, all content generated through the game, including audio, visuals, and educational content, could be shared in an integrated social network to further promote connection, creativity, and learning between gamers and musicians.

8. Conclusions

To conclude, *Juke* is an innovative browser-based audiovisual game with potential applications in entertainment, music content creation, and education. It was born through an iterative design process that demanded a wide range of technologies, including music creation software, animating software, adaptive audio software, and various coding languages. Through further refinement and development, the project aims to foster connection, creativity, and learning between musicians and gamers.

Appendix A: Weekly Gantt Chart for Culminating Experience

Phase	Week Beginning	Task
I	12/20/20	Seek game design advice from supervisor
	12/27/20	Seek game design advice from former students
	1/3/21	Create Game Design Document
	1/10/21	Create prototype sketches
	1/17/21	Complete the "Unity Essentials" track on Unity Learn (1/2)
	1/24/21	Complete the "Unity Essentials" track on Unity Learn (2/2)
	1/31/21	Gain familiarity with Unity (1/2)
	2/7/21	Gain familiarity with Unity (2/2)
	2/14/21	Gain familiarity with Unity/FMOD
	2/21/21	Reach out to students in the Masters for Scoring for Film, Television, and Video Games (SFTV), requesting a unique musical score to accompany the game
2/28/21	Decide whether game will include original music or audio samples	
II	3/7/21	Design simple prototypes for the game engine in Unity
	3/14/21	Explore different visualization options for the waveform
	3/21/21	Explore different audiovisual mapping possibilities (1/2)
	3/28/21	Explore different audiovisual mapping possibilities (2/2)
	4/4/21	Seek feedback on prototypes and iterate (1/4)
	4/11/21	Seek feedback on prototypes and iterate (2/4)
	4/18/21	Seek feedback on prototypes and iterate (3/4)
	4/25/21	Seek feedback on prototypes and iterate (4/4)
III	5/2/21	Refine prototype (graphics)
	5/9/21	Refine prototype (audio)
	5/16/21	Decide on final prototype
	5/23/21	Flesh out prototype (graphics)
	5/30/21	Flesh out prototype (audio)
	6/6/21	Optimize prototype for elegant graphics
	6/13/21	Optimize prototype for high-quality, immersive audio
	6/20/21	Optimize prototype for elegant graphics and high-quality, immersive audio
	6/27/21	Finalize game prototype
	7/4/21	Present and defend the CE

Appendix B: Resources

NAME OF RESOURCE	ROLE
PEOPLE	
Marta Verde	CE Supervisor
Musicians	Composing and recording music for the game
PLACES	
Ann Kreis Scoring Stage (AKSS)	Recording original soundtracks for the game
SOFTWARE	
Unity (free student license)	Creating the game prototype
p5.js (free and open-source)	Prototyping audiovisual interactions
Ableton Live	Source of audio samples during prototyping
Adobe Creative Suite	Prototyping and sketching visualizations in Illustrator/Animator/Photoshop
Procreate	Prototyping and sketching visualizations and sprites
Google Drive	Storing files related to the CE
HARDWARE	
MacBook Pro	Prototyping and creating the game
Hard Drive (2 TB)	Storing files related to the CE

Appendix C: Budget

ITEM	PROPOSED	REAL
MATERIALS (disposables)		
Hard Drive	\$50	\$0
EQUIPMENT		
HARDWARE		
MICS (Rental) 6 days	\$200	\$0
INTERFACE (purchase) 120 days	\$700	\$0
COMPUTER (purchase) 120 days	\$2,500	\$0
SOFTWARE		
ABLETON LIVE (purchase) 120 days	\$449	\$0
PROCREATE (purchase) 120 days	\$10.99	\$0
ADOBE CREATIVE SUITE (purchase) 120 days	\$212	\$0
PERSONNEL		
COMPOSER/ARRANGER	\$1,000	\$0
MUSICIANS	\$1,200	\$0
ENGINEER	\$300	\$0
MIXER	\$300	\$0
EDITOR	\$300	\$0
STUDIO		
BERKLEE daily x # of days	\$4,000	\$0
HOME daily x # of days	\$400	\$0
CATERING		
MEALS cost/person x #persons x meals	\$450	\$0
OVERHEAD		
RENT	\$700	\$0
POWER	\$50	\$0
WATER	\$25	\$0
GAS	\$25	\$0
INTERNET	\$10	\$0
PHONE	\$10	\$0
FEES		
YOUR FEE	\$500	\$0
TOTALS	\$13,391.99	\$0

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