STORYTELLING WITH MUSIC:

Adaptive Music in Video Games and Beyond

by

Emad Saedi

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Abstract

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Emad Saedi

Master of Digital Media in the program of Digital Media, Ryerson University, 2020-2021

Music plays an essential role in storytelling within video games. Unlike motion pictures, which use linear music, video games need adaptive music because of their nonlinear nature. Since adaptive music can change according to specific rules in response to the player's input, it makes an immersive experience for the players.

Using the research-creation method, this research studied various techniques to produce adaptive music, including two main approaches, vertical and horizontal mixing and procedural music. To better understand adaptive music and its challenges, the researcher studied the soundtrack of the video game Gorogoa composed by Joel Corelitz as a case study and conducted creative research by composing adaptive music. The author found a new criterion called *compatible loops*, a great way to compose adaptive music for video games that presents the concept of *player-as-composer*. It is also ideal for composing musical soundscapes and long dynamic ambient tracks. This study also found that the distinction between music and the soundscape has been reduced, and adaptive music can be practical as the soundscape in real settings such as urban areas. Music gamification using adaptive music techniques can also provide innovative services for digital environments other than video games.

Keywords:

Adaptive music, video games, storytelling, Gorogoa, soundscape, Immersion, procedural music, vertical and horizontal mixing, looping, gamification, compatible loops

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Finally, I want to thank my parents and my dear brother, Amir Bahador, for their everlasting support and encouragement. None of this could have been possible without their support.

Dedication

I dedicate this research to my father, my mother, and my brother.

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Thesis Statement

The purpose of this research is to recognize the role of adaptive music in video games, figure out how it works, identify its challenges, and suggest new solutions. The author believes that adaptive music – the way presented in video games – can impact other industries and provide services beyond video games to create new experiences for us.

Contributions

This research:

- Reviews the history of storytelling with music
- Analyzes the relationship between the soundscape and music
- Provides a comprehensive review of adaptive music, including its definition, role in video games, compositional approaches, and challenges
- Studies the soundtrack of the video game Gorogoa
- Interviews Joel Corelitz as an industry expert and a member of the research committee
- Introduces audio strategy
- Introduces compatible loops
- Introduces the player-as-composer concept
- Extends the research criteria of adaptive music and video games

This study contributes to academia, video game, and music industries. The content of this paper can be helpful for research and educational purposes. Also, it could be a reliable resource for professionals such as composers, sound designers, and video game developers who want to step into the world of adaptive music.

The purpose of this research is to recognize the role of adaptive music in video games, figure out how it works, identify its challenges, and suggest new solutions. The author believes that adaptive music – the way presented in video games – can impact other industries and provide services beyond video games to create new experiences for us.

Introduction

When the COVID hit the world, I had just received an offer of admission to the Master of Digital program. The worldwide disaster disrupted my admission and visa process. During these stressful times, I took refuge in video games to relieve my anxiety and protect my mental health, and I played video games more than ever, the whole spring and summer of 2020.

I played some of the most respected games of video game history in a row: *Red Dead Redemption 2* (*RDR 2* [2018]), *Spider-Man* (2018), *The Last of Us Remastered* (2014), *God of War* (2018), *Journey* (2012), *Monument Valley 2* (2017). As I played more, I noticed something fascinating about the soundtrack in some of these games. It did not matter how long my rides took in RDR 2 or how many streets I passed, shooting webs and swinging in Spider-Man. The music kept playing and adapting to my actions and the environment seamlessly. For example, if a peaceful horse riding turned into a shoot fight in RDR 2, music became more energetic and active to add tension and excitement. The adaptive music significantly impacted the narrative and created an immersive experience for me.

I have always been fascinated by storytelling with music in films and video games. A good soundtrack reveals the visually untold story and works with all other elements in harmony to stay true to the story and convey it in the best possible way. Thanks to technology, music can now be more dynamic and enhance the player's experience. Adaptive music is a trend in video games today (Nuanain, 2019). Deciding when to change the music and how to change it seamlessly is a highly complex and complicated problem because of the unpredictability of gameplay. Therefore, as a composer, producer, and sound designer passionate about storytelling with music and sound, I decided to figure out what adaptive music is, how it works, and identify its challenges. My supervisor, Dr. Kristopher Alexander, suggested a deep dive into adaptive music by studying the soundtrack of the video game *Gorogoa* (2017) and doing hands-on work. This

paper presents my findings regarding adaptive music, the relationship between soundscape and music, and new horizons for creating and consuming adaptive music.

Literature Review

In the literature review, we will get acquainted with storytelling with music and music in video games. Before discussing anything, we need to understand the musical terms used in this research. Since these terms require deep understanding, I have dedicated the first section of the literature review to music terminology. My primary reference for explaining essential music theory terms was the book *Music an Appreciation* by Roger Kamien (1976).

1. Music Terminology

Rhythm

Although *rhythm* might seem an obvious matter, it is such a complex concept that there are various definitions for it, and there are arguments over those definitions, too. In fact, a generally accepted definition of rhythm does not exist (Deutsch, 2013). Kamien (1976) uses the analogy of life to describe rhythm:

> Rhythm is basic to life. We see it in the cycle of night and day, the four seasons, the rise and fall of tides. More personally, we feel rhythm as we weather. We find it in our heartbeats and our walking. – Rhythm forms the lifeblood of music, too; it orders the flow of music through time. It also seems to pass at varying speeds and intensities. Yet there is an essential difference between music and life. A composer can control the passage of time in music. (p. 34)

Rhythm is putting music into a timely, organized manner. As Kamein says, “the essence of rhythm is a recurring pattern of tension and release, expectation and fulfillment.” Rhythm can be found “everywhere in music – in pitch, tone color, and volume. How these elements change in time, and their rate of change, are concerns of rhythm.” (p. 34)

Tempo

To explain *tempo*, first, we need to understand the *beat*. “The beat is a regular, recurrent pulsation that divides the music into equal units of time” (Kamien, 1976, p. 34). Tempo shows the speed of the beat and defines the pace of the music. “A fast tempo is associated with a feeling of energy, drive, and excitement. A slow tempo often contributes to a solemn, lyrical, or calm mood” (Kamien, 197, p. 37).

Melody

We recognize Beethoven’s *Fifth Symphony* (1808) with its famous opening notes: “*Da-da-da-dan!*” That is the *melody*. For a lot of us, the melody is what we remember a piece of music by. Powerful melodies affect us emotionally, and familiar melodies can recall memories and past experiences. Although I initially used the Beethoven symphony example, Kamien (1976) says that words and instruments are not required to create or remember melodies; we do not need singers and large orchestras. Just a few notes are enough. He believes that melody is easier to recognize than define. How do we recognize melody? “Probably the exclusive “something” that evokes so much feeling will never be trapped for a dictionary” (p. 45).

The melody consists of a series of single notes that create a recognizable whole together. Melody is alive; it has motion and an arc. As Kamien (1976) says, “a melody begins, moves, and ends; it has direction, shape, and continuity. The up and down movement of its pitches conveys tension and release, expectation and arrival. This is the melodic curve or line.” (p. 45) Not all pieces have a melody, however. We may recall some pieces by their character of sound or atmosphere, which is the discussion of soundscape in the following sections.

Motif

Melodies consist of shorter parts called *phrase*, *motive*, or *motif*. The motif is the core of the melody. These short units may share similar pitch and rhythmic patterns that help unify a melody (Kamien, 1976).

Variation

Variation means reproducing music in different forms. Melody or motifs might create the basis to create new musical phrases by changing the original material. Variation may involve changes in rhythm, harmony, tempo, melody, and other characteristics of music. However, the core of the music will be the same, and its theme will be recognizable throughout the whole variations.

Theme

A melody may create the foundation to compose an extended piece of music. The composer can compose a whole piece by developing the melody, creating variations, or using other music development techniques. Such a melody is called a *theme* (Kamien, 1976).

Movement

Some music works consist of several individual sections called *movements*. While these sections are separate and different in melody, harmony, rhythm, tempo, and other musical factors, they add up to a whole, and the player must perform all of them in order.

Pitch and Tone

Kamien (1976) defines *pitch* and *tone* as follows:

> Pitch is the relative highness or lowness that we hear in a sound. The pitch of a sound is defined by the frequency of its vibrations. The faster the vibrations, the higher the pitch; the slower the vibrations, the lower the pitch. In music, sound that has a definite pitch is called a tone. (p. 2)

Music Notation

Notation is the alphabet of music. By writing down music, pitches, rhythms, and expressions can be communicated. Seven of the twelve pitches in *Western* music played on the piano white keys are named after the first seven letters of the alphabet: *A, B, C, D, E, F, G*.

The C is at the middle of the piano's range and is nearest to the center of the keyboard. Therefore, it is usually the reference note, and musicians order the notes as C, D, E, F, G, A, B. These are English equivalents to the original names of the notes in Italian: *do, re, mi, fa, sol, la, ti, do*. This sequence is repeated in higher and lower octaves, duplicating the same tones in higher and lower frequencies.

The five other tones, played on the piano's black keys, are indicated by the same seven letters plus a *sharp* (♯) or a *flat* (♭) sign. A *natural* sign (♮) cancels a previous sharp or flat sign. The sharp sign indicates a half step higher, and the flat sign indicates a half step lower. The half step is the smallest distance between two notes in Western music (Kamien, 1976).

Interval

The difference in pitch makes the two tones sound different. “The “distance” in pitch between any two tones is called an *interval*. When tones are separated by the interval called an *octave*, they sound similar” (Kamien, 1976, p. 3).

As explained before, The smallest interval in western classical music is a half-step, resulting in eleven unique tones and twelve tones in an octave range. There are smaller intervals in other cultures. For example, Persian classical music applies quarter step intervals in addition to half steps. However, we focus on Western music for this paper.

Scale and Key

Familiar melodies gravitate toward a *central tone*. The central tone is “stable” and “restful,” and music usually ends on this tone. This central tone is called “the *keynote* or *tonic* of the melody” (Kamien, 1976, p. 53). A piece in the key of C has C as the tonic. Tonic is relative to other tones and can be any of the twelve tones within an octave.

Key or *tonality* involves a central tone, *scale*, and *chord*. For example, the key of C has C as its tonic, C-D-E-F-G-A-B (or do-re-mi-fa-sol-la-ti-do) as its basic scale (C *major*), and a *triad* based on its tonic.

Kamien (1976) explains scale as follows:

> A scale is made up of the basic pitches of a piece of music arranged in order from low to high or from high to low. Many different scales have been used in various eras and cultures. The basic scales of Western music from the late 1600s to 1900 were the *major* and *minor*. And these scales have continued to be widely used during our own century. (p. 54)

Other tones of a piece of music are heard and interpreted relative to the tonic. However, not all pieces of music are strictly framed in these traditional rules. “After 1900, some composers abandoned the traditional system, but even today, much of the music we hear is built around a central tone, chord, and scale” (Kamien, 1976, p. 54). This study focuses mainly on the traditional major and minor scales (the octatonic system with eight notes per octave).

Chord

When a group of three or more notes is played simultaneously, they make up a chord. “The simplest, most basic chord is the triad (pronounced “try-ad”), which consists of three tones” (Kamien, 1976, p. 51). For example, C-E-G is a triad with C as its root.

Functions

By hearing certain chords, we can recognize the key and scale of the piece. These chords have unique qualities that are functional to a specific key. For example, by hearing triads C, F, and G, we know that the piece is in the key of C. The chord built on the first tone of this scale is called *Tonic* (*I* or *T*), the chord built on the fourth tone of this scale is called *Subdominant* (*IV* or *S*), and the chord built on the fifth tone of this scale is called *Dominant* (*V* or *D*). Tonic, Subdominant, and Dominant are fundamental functions of any scale. Any key and scale have their unique *functions*.

Harmony

Harmony is the science of chords and their relationship with each other. Using harmony makes the music sound richer. Kamien defines harmony as “the way chords are constructed and how they follow each other” (1976, p. 49). Melody usually provides clues for harmonizing. These clues are the tones from the melody that are included in the chords which might accompany them. However, there is not a definite correct harmony, series of chords, or *chord progression* for a melody. A melody can be harmonized in different ways. Therefore, the same melody can project various feelings using different chord progressions. “Chord progressions will enrich a melody by adding emphasis, surprise, suspense, or finality” (Kamien, 1976, p. 49).

Modulation: Change of Key

Most short melodies stay in one key. However, in longer pieces of music, the composer may travel to other keys to add variety, contrast, and color to the piece and create new feelings and a better listening experience. For example, a piece may begin in D major and end up in B ♭ major. This shift between keys is called *modulation* (Kamien, 1976).

Tonal and Atonal Music

Tonal music follows strict harmony rules, and the music gravitates towards a central tone or tonic, as explained in the Scale and Key section. *Atonal* is the opposite. It simply means “not tonal” (Neugebauer, 2014, chap. 29). It does not apply tonal harmony rules. Atonal harmony treats all tones, melodies, and chords equally and takes advantage of all twelve tones in Western music. It means that a piece in atonal harmony does not have a key and is not in a major or minor scale either. Such a piece may involve all twelve tones.

Musical Texture

Musical texture refers to the relationship between different layers of sound in music. The texture of a single melodic line is *monophonic*. When two or more melodic lines are performed simultaneously, they create a *polyphonic* texture. Finally, a melody accompanied by chords produces a *homophonic* texture (Kamien, 1976).

Stems

When producing music, audio lines including musical and non-musical tracks called *stems* are arranged to form music. Stems give the composer great control over the whole piece to rearrange it.

Loop

Loop is a piece of audio that can be repeated. Musicians can layer several loops on top of each other to develop a more complex loop. Loops enable artists to produce full-length tracks by repeating, layering, and arranging shorter parts together. Also, artists may create and play premade loops to accompany themselves in performance or loop what they already play in real-time in order to play along with it. The act of creating, modifying, and playing loops is called *looping*.

Loops give the composer a lot of flexibility and freedom. However, harmony and rhythm are major limiting factors to the composition and structure. Because loops should be harmonically and rhythmically compatible. Today, music production software known as *DAW* (*Digital Audio Workstation*) and *loop machines* give artists the ability to create and play loops.

Many mainstream songs in diverse genres, including Pop and Rock, use loops and *sequencing* nowadays. Sequencing is the repetition of a melodic pattern on a higher or lower pitch (Kamien, 1976). “Today, repetition is not only the main building block of a number of musical genres, the careful balance of repetition and variation is also the base of most rhythm games” (Pichlmair & Kayali, 2007, p. 3).

Soundscape

The *soundscape* is a collection of sounds that we remember something by, including but not limited to places, cultures, and people. Schafer defined, “the soundscape is any acoustic field of study” (Schafer, 1993, chap. The Notation of Soundscapes [Sonography]). According to his definition, a piece of music, a radio program, the noise of a cafe downtown, the sound of the forest, any acoustic environment can be a soundscape. He used the analogy of photography to explain the study of the soundscape:

> We can isolate an acoustic environment as a field of study just as we study the characteristics of a given landscape. However, it is less easy to formulate an exact impression of a soundscape than of a landscape. There is nothing in sonography corresponding to the instantaneous impression which photography can create. With a camera, it is possible to catch the salient features of a visual panorama to create an impression that is immediately evident. The microphone does not operate this way. It samples details. It gives the close up but nothing corresponding to aerial photography. A soundscape consists of events heard, not objects seen. (chap. The Notation of Soundscapes [Sonography])

In the definitive *Handbook for Acoustic Ecology*, Truax (1999) presented another definition of soundscape that focuses on the relationship between the sonic environment and the engaging person:

> An environment of sound (or sonic environment) with emphasis on the way it is perceived and understood by an individual, or by a society. It thus depends on the relationship between the individual and any such environment. The term may refer to actual environments or to abstract constructions such as musical compositions and tape montages, particularly when considered as an artificial environment.

Speaking of the uniqueness of the way soundscape is perceived and understood, Truax (2008) raised an important question: Is soundscape a shared global experience? He suggests that "*hi-fi* soundscapes are varied and uniquely local; *lo-fi* soundscapes are uniform and about the same everywhere" (p. 2).

Regarding the aesthetic aspects of soundscape, there has been an ongoing debate. Drever (2002) presented four main characteristics of soundscape compositions in his research, concluded from Truax (2000):

> (1) Listener recognisability of the source material is maintained, even if it subsequently undergoes transformation; (2) The listener's knowledge of the environmental and psychological context of the soundscape material is invoked and encouraged to complete the network of meanings ascribed to the music; (3) The composer's knowledge of the environmental and psychological context of the soundscape material is allowed to influence the shape of the composition at every level, and ultimately the composition is inseparable from some or all of those aspects of reality; (4) The work enhances our understanding of the world, and its influence carries over into everyday perceptual habits. (p. 2)

The intersection of soundscape and music first happened in the late 1960s when R. Murray Schafer (1969, 1977) suggested the concept of "the soundscape as the 'universal' composition of which we are all composers" (Truax, 2008, p. 1). This concept led to the formation of the *World Soundscape Project* (*WSP*) at Simon Fraser University in Vancouver in the early 1970s.

The outcome of the WSP was a double *LP* (*Long Playing* vinyl record, an album), entitled *The Vancouver Soundscape*. Each of the tracks explores different audible aspects of Vancouver: "its geography, its people, its identity" (Drever, 2002, p. 2). Schafer (1973), the director of the WSP at that time, included this introduction with the original LP:

> To record sounds is to put a frame around them. Just as a photograph frames a visual environment, which may be inspected at leisure and in detail, so a recording isolates an acoustic environment and makes it a repeatable event for study purposes. The recording of acoustic environments is not new, but it often takes considerable listening experience to begin to perceive their details accurately. A complex sensation may seem bland or boring if listened to carelessly. We hope, therefore, that listeners will discover new sounds with each replay of the records in this set – particularly the first record, which

> consists of some quite intricate environments. It may be useful to turn off the room lights or to use headphones, if available. Each of the sequences on these recordings has its own direction and tempo. They are part of the *World Symphony*. The rest is outside your front door.

The efforts of this social science research group, consisting of composers R. Murray Schafer, Barry Truax, and Hildegard, shaped a new genre of music (Drever, 2002). Today, the soundscape and music are blending. Composers are using non-musical sounds musically to create special vibes in their music or create *sound worlds* with their music. It is not only about music itself but also about the sound snapshot we take from places. One may remember a cafe by hearing a piece of music that used to be played there. It means music and soundscape are blending as composition, and music is becoming part of our lives' soundscape. In other words, the soundscape is becoming music, and music is becoming the soundscape. Although, Truax (2008) suggested that we should not treat music and the soundscape similarly:

> Music created through soundscape composition cannot be organised with much similarity to instrumental music; in fact, a broader definition of music such as 'organised sound' must be invoked if soundscape composition is to be included. (p. 2)

In an article by Sophie Haigney (2019) published in Topic titled *How Ambient Chill Became the New Silence*, she suggested that ambient background music has become part of the urban life soundscape that intends to change consumer's behavior:

> Background music comes in a variety of flavors: piped-in playlists curated by sound designers for hotels or fast food restaurants; custom-made background music for big-budget commercials; algorithmic Spotify playlists with chill, lo-fi beats; and stock music, which permeates our environment often imperceptibly, in airports, Instagram Stories, furniture showrooms, grocery stores, banks, and hospital lobbies.

> Adding ambient music to these spaces is about setting and controlling a nearly invisible emotional forcefield for consumers; ambient music for shopping spaces, these days, is meant to soothe you or pump you up, and generally nudge your habits toward consumption. (para. 4)

Film composer Hans Zimmer (2017) speaks about using soundscape as music by creating sound worlds and unique sound palettes for different atmospheres in film music. He advises composers to study light and color to understand the relationship between music and space better.

The modern example of music as soundscape is the *jingles* of Tokyo train stations composed by Minoru Mukaiya. He has composed over 200 unique jingles for 110 stations which each one sets the vibe of a station, and people can recognize the station by hearing its tune (May, 2020).

The soundscape has found its way to video games as well. In a video, Composer Martin Stig Andersen (2019) explained how he created soundscape compositions as the soundtrack for the video games Limbo (2010) and Inside (2016).

2. Storytelling with Music

Man has been using music to tell stories and convey tales from generation to generation for a long time in history. Until the seventeenth century in Europe, words and vocal music served the primary role for musical storytelling. Roger Kamien (1976) reflects on this in his book, Music an Appreciation, that singing has been the most common way of making music throughout history, “because the singer becomes an instrument, we identify with him or her especially – a human body like our own expressing emotions through sounds and words.” He believes that “the voice’s unique ability to fuse a word with a musical tone is the reason that poetry and singing have been inseparable in many cultures” (p. 10).

Word-painting

Renaissance composers used a technique called *word-painting* to transform words and images into music. Since vocal music was mainstream and more important than instrumental music at the time, the technique was widely used for vocal music. Word-painting is a musical representation of specific poetic images. “For example, the words *descending from heaven* might be set to a descending melodic line, and *running* might be heard with a series of rapid notes” (Kamien, 1976, p. 101).

Baroque composers also used this approach in their music to convey the meaning of specific words. For example, “*heaven* was set to a high tone, and *hell* to a low one. Rising scales represented upward motion, while descending scales depicted the reverse.” One way of emphasizing words was to write “many rapid notes for a single syllable of text” and repeat individual words and phrases repeatedly as music continuously unfolds. (Kamien, 1976, pp. 120-121)

Later, when musicians invented *Opera* and *Oratorio* in the seventeenth century, a new era began for musical storytelling. They started to combine music with other forms of art and use platforms like theater to tell stories more creatively.

Opera

Opera was formed in Italy around 1600 and is considered a significant development in music. Kamien (1976) defines *opera* as “the drama that is sung to orchestral accompaniment” (p. 136). Opera employs several art forms, such as music, acting, poetry, dance, scenery, and costumes, to create a “theatrical experience of overwhelming excitement and emotion” (Kamien, 1976, p. 136).

As mentioned before, vocal music was more important than instrumental music then. Hence, opera story, characters, and plots are revealed through vocal music as a song rather than the speech used in ordinary drama. This approach is pleasing to the ear and increases the emotional effect of the words and story. The flow of the music carries the story forward and makes the story believable. As Kamien (1976) says, “music makes even a complicated plot believable by depicting mood, character, and dramatic action – In opera, the music *is* the drama.” (p. 136). Mozart’s *The Magic Flute* (1791), *Marriage of Figaro* (1786), and *Don Giovanni* (1787) are amongst the greatest and most popular operas in history.

Oratorio

The oratorio is another major development in Baroque vocal music alongside opera. Oratorios first appeared in Italy, at about the same time as opera, in the early seventeenth century “as musical dramatizations of biblical stories” (Kamien, 1976, p.171). They were performed in prayer halls called *oratorios*. Although biblical stories inspire most oratorios, they do not serve religious purposes usually.

Like opera, the oratorio is sung to the orchestral accompaniment and is set to a narrative text. However, it does not employ acting, scenery, or costumes. In an oratorio, a narrator usually relates the story and connects one piece with another using recitative, a form of singing close to speech. Oratorios are long (sometimes over two hours) and have more of a storyline. Handel’s *Messiah* (1741) has been the most favorite and best-known oratorio for decades (Kamien, 1976).

Storytelling with Instrumental Music

Words and vocal music are not the only ways to tell stories with music. The music itself has many potentials. By the end of the seventeenth century, with the advent of new musical forms,

musicians found new ways to tell stories as effectively as with words only with instruments. Kamien (1976) writes, “Until the late 1600s, the most important music of Western culture was vocal. But by the end of the seventeenth century, instrumental music was greatly developed and had become as important as vocal music” (p. 11).

Composers in this era invented new forms like the *sonata form* (sometimes called *the sonata-allegro form)* that allowed them to tell stories creatively in an organized, standardized way. Kamien (1976) clarified that the term sonata form should not be confused with the term *sonata*. Sonata form refers to the form of a single movement versus sonata, which describes a whole composition made up of several movements. As introduced in Music an Appreciation (Kamien, 1976), a sonata form movement consists of three main sections:

1- The *exposition*, where the themes are presented;

2- The *development*, where themes are treated in new ways;

3- The *recapitulation*, where the themes return. (p. 197)

These three main sections are often followed by a concluding section, the *coda* (Italian for tail). Sonata form is usually used in the opening movement of Classical symphonies, sonatas, and string quartets. Much of great music from the Classical period to the twentieth century is composed in sonata form. (Kamien, 1976, p. 197)

This structure is similar to the basic written essay form we see in many storybooks and novels: Introduction, body, and conclusion. Such similarities bring music and storytelling even closer.

Beethoven’s Fifth Symphony has often been associated with *fate*, and people interpret it as the story of life. The reason this symphony carries this epithet is because of Beethoven’s secretary and biographer, Anton Schindler. It is said that when he asked Beethoven about the opening

motif of the symphony, he responded, “this is the sound of fate knocking at the door” (Reucher, 2018; H. Gibss, 2006). Roger Kamien (1976) explained the *narrative arc* of the Fifth Symphony:

> The Fifth Symphony opens with one of the most famous rhythmic ideas in all music, a short-short-short-long motif. Beethoven reportedly interpreted this four-note motive as “Fate knocking at the door.” It dominates the first movement and plays an important role later in the symphony, too. The entire work can be seen as an emotional progression from the conflict and struggle of the first movement, in C minor, to the exultation and victory of the final movement, in C major. The finale is the climax of the symphony; it is longer than the first movement and more powerful in sound, employing three trombones. (p. 245)

With such innovations, more composers started to compose to tell stories specifically. Korsakov’s *Scheherazade* (1888) and *Flight of the BumbleBee* (1900), Tchaikovsky’s *The Nutcracker* (1892), Saint-Saëns’s *The Carnival of the Animals* (1886), and Holst’s *The Planets* (1916) are great examples of storytelling with instrumental music.

Modest Mussorgsky’s *Pictures at an Exhibition* (1874) was indeed an innovation in storytelling with music. Each movement describes a picture in an art gallery, and *promenade* sections in between the main movements indicate walking through the exhibition (Young, 2012).

Storytelling with Music for Media

The previously discussed era significantly influenced music for narrative platforms such as theater, film, and video games. With the advent of *motion pictures* in the twentieth century, great classical composers like Max Steiner, Bernard Hermann, Shostakovich, Henry Mancini, Nino Rota, Alfred Schnittke, and Jerry Goldsmith started to compose for the picture and tell a parallel story with their music. Storytelling with music is an independent professional career today. Film

composers, video game composers, and commercial composers (advertisements, jingles) are soundtrack composers.

The main job of a soundtrack composer is to compose the original soundtrack to accompany the desired story told in a usually non-musical context, in another form of content. Ennio Morricone, John Williams, Alan Silverstri, Danny Elfman, Howard Shore, Hans Zimmer, James Horner, John Powell, Ramin Djawadi, Philip Glass, Max Richter, Austin Wintory, Jesper Kyd, Martin O'Donnell, Jeremy Soule, Lorn Balfe, Harry Gregson-Williams, James Newton Howard, Benjamin Wallfisch, Thomas Newman, Rachel Portman, Maurice Jarre, Joe Hisaichi, and Bryan Tyler, are only a few of influential soundtrack composers of our era.

Soundtrack

The *soundtrack* is a collection of audio tracks – including music – that serves another medium rather than audio or music themselves. Deutch defines the soundtrack as "intentional sound which accompanies moving images in narrative film" (Deutsch, 2007, p. 1).

The soundtrack is a fundamental element of a movie. Gorbman (1976) has specified *cinematic codes of signification* in film derived from Louis Delluc's writings. Louis Delluc recognized "the five material bases for the systems of signifiers that interact to form filmic discourse" in his writings from cinema *matières d'expression* that includes soundtrack as well:

> On the image-track there are (1) the photographic images themselves, and (2) "mention écrites," or written (linguistic) material within the images. On the soundtrack, there is (3) verbal sound (dialogue, song lyrics, etc.), (4) noise or sound effects, and (5) music. (chap. Teaching The Soundtrack)

We know that the soundtrack is meant to accompany narrative content. Today, the word *soundtrack* commercially refers to the original music written for narrative content. In this article,

we use the word *soundtrack* in its commercial meaning. The soundtrack covers a broad range of media and is not limited to films, such as video games, podcasts, and events and experiences.

The connection between the soundtrack and the story is vital. Regarding this, Hans Zimmer, the award-winning composer with 169 successful scores (IMDb, 2021), said, “I can tell you everything that you need to know in one word: story” (Zimmer, 2017, Ep. 3 Story). He believes that a composer should relate to the characters and the story by “*method composing*,” similar to actors who practice *method acting*. Zimmer explained Jack Sparrow’s theme as an example. His character was described with keywords like “romantic, heroic, naughty, wicked” (Ep. 15-17 Character Themes). Therefore, he tried to compose a theme that resonates with such characteristics.

The connection, as mentioned earlier, is so important that Zimmer said, “It doesn’t matter that you’ve just written the nicest and most beautiful piece of music of your career. If it interferes with the story, bin it, chuck it, throw it in the trash” (Ep. 10 Scoring Under Dialogue). The connection of music and story is not limited to the film soundtrack. He believes “there is a *narrative arc* in any good music.” (Ep. 27 Hans’s Journey)

However, the soundtrack should not necessarily imitate the dialogues and the story of the picture. It can complete the story by telling the visually untold parts. Regarding the uniqueness of the soundtrack, Zimmer described the film music as it tells “a *parallel story*, expressing what cannot be put into words.” He showed the narrative power of music by creating question-and-answer-like musical phrases. “I think there’s a natural way in music where you’re basically having a conversation,” Zimmer said (Ep. 2 Themes).

3. Music in Video Games

Music is one of the most emotional influencers in media-based storytelling, and it is used to a great extent in motion pictures where the soundtrack plays a fundamental role in the narrative. The interactive nature of video games allows for more possibilities with music. In video games, music reacts to the player's action in *real-time* to communicate feelings more deeply (Young, 2012).

Video games are interactive, nonlinear storytelling platforms. The core of video games is the player's input. Because of this, video games contain elements of variability and unpredictability. As a result, the timing of in-game events is variable, and the order of player's choices is unpredictable. A player might solve a puzzle within a few moves in a short amount of time, while it might take several tries and hours for another player to solve. Young (2012) wrote, "the inherent 'human' variability and cause-and-effect-based outcomes result in unique and unpredictable gameplay experiences for users" (p. 5)**.** Such unpredictable nature affects the narrative as well as the audio.

Unlike film and television, audio in video games serves an active function. Sometimes, the player needs to listen carefully to catch clues and respond correctly. Otherwise, it may result in losing the game or points (Collins, 2007). Video game music often features some of the characteristics of *ambient music* to keep the balance and avoid distraction from the game (Thibault, n.d.).

In most modern video games, music shows *adaptive* behavior (Hutchings & McCormack, 2020). It means that music in video games is required to adapt to the state of the game according to predefined rules. This kind of music that is constantly changing in real-time is referred to as *nonlinear music*. (Fay et al., 2004; Fernandez, Vico, 2013) Video games sound is often referred

to vaguely as “*interactive*,” “*adaptive*,” or “*dynamic*” (Collins, 2007, p. 2). In this study, I use the general term *adaptive music*. Although I introduced it here briefly, I will elaborate more on it further in the Adaptive Music section of this paper.

Technological restraints have mainly influenced video game music. At first, it was part of the game code and was composed by programmers and not by music experts (Thibault, n.d.). Game audio before the early 1990s was generated with limited sound chips. Young (2012) described the characteristics of the sound of these chips, “the resultant audio produced through these means possessed a highly synthetic aural aesthetic, sometimes referred to as “*8-bit*, *Chiptunes*, or *Chip Music”* (p. 20).

In the 70s and 80s, the video game Chiptunes became so popular that it gave birth to a genre. Chiptunes was firstly influenced by electronic music. However, later, it influenced electronic music. Below are four main characteristics of this genre exactly as Thibault (n.d.) described:

> 1- The pieces were composed to be played repeatedly through all the game, without ending or fading away;
>
> 2- The pieces lacked of lyrics;
>
> 3- The pieces were played over the games' sounds;
>
> 4- They had a limited polyphony (e.g. Nintendo Entertainment System could only play a maximum of three tones at once). (para. 3)

With the advances in technology, gaming consoles and personal computers are capable of playing any kind of music nowadays. Hence, video games can feature technically complex soundtracks, combining high-quality tracks, changing instantly, and adapting to the game status in real-time according to the player’s input (Thibault, n.d.).

Adaptive music in video games is becoming more commonplace since it provides greater *interactivity* to game music (Plut & Pasquier, 2020). Investment in music production for video games is as important as investing in film music and is necessary for the development of the video game industry. Video game music, which applies *gamification* to music, has resulted in music production for video games being a “state-of-the-art research field in computer science” (Margounakis et al., 2017, p. 1).

Linear vs. Nonlinear

I discussed video game music being nonlinear before. To better understand it, we should first know what *linear music* is. Linear music has been with us for a long time. In fact, most music we hear is linear. Collins (2007) used train track analogy to explain linear music: “Like being locked onto a straight train track, it has been composed to start at one point, and progress to another point” (p. 1). Farnell (2007) described, “something that starts at one point and moves at a constant rate to another is deemed linear” (p. 2).

Linear music has a determined beginning, end, and, therefore, duration. Everything has been decided already, from melodies, dynamics, pitches, rhythms, and no musical changes can be made to the composition. Everything is fixed in its place, and the pieces are arranged with such properties in mind. This is neither an advantage nor a disadvantage. The characteristic of linear music makes it perfect for linear media like movies, in which duration is fixed and scenes are predefined. Linear music enables the composer to use their most artistic potential and compose a well-thought-out piece.

Nonlinear music is kind of the opposite. Collins (2007) described, “like a major urban metro” (p. 1). You may change the train at one station and go in a new direction with another train. You may leave the new train at any station or go to the end of the line. The train might speed up or slow down depending on the traffic, and so on. Nonlinear music acts similarly. It allows change

and may go in various directions at different paces. It is entirely dynamic and flexible. Farnell (2007) said, “interactive audio uses further input to start new sounds or change existing ones, and the value of the input affects the quality of sound produced. Something that can jump between a number of values in any order (discontinuous) or move at different rates or in different directions is nonlinear” (p. 2).

Adaptive Music

Adaptive music, as the name suggests, adapts to the context. It is nonlinear and transforms in real-time. Brown and Kerr (2009) defined it as follows: “Adaptive Music reorganizes existing musical material so as to produce new musical experiences based on that material” (p. 1).

As discussed before, video game music and hence, adaptive music have been influenced by technology restraints. In other words, technology has made adaptive music possible. Adaptive music can be entirely *generated* by a computer or be composed by an actual human and *assisted* by a computer. I will elaborate more on this in the *Compositional Approaches* section. However, at the core, adaptive music employs similar techniques used by notational composers to conduct musical variation. Therefore, the techniques for adaptation are based on familiar musical concepts such as pitches and rhythms and operate, primarily, on symbolic representations of music (Brown & Kerr, 2009).

Although we may use synthesizers or virtual instruments to produce linear music nowadays, traditional music is based on recording. We capture real sound signals with a microphone and process them into a final form. A recording, a piece of music, or sound effects track created this way is fixed and cannot be modified anymore (Farnell, 2007). However, according to Brown and Kerr's definition of adaptive music, even fixed recordings can be reorganized to create adaptive music. It means that adaptive music is not necessarily generated by the machine, and we

shouldn't confuse *fixed* audio with *linear* music. We can use fixed audio components (stems) to produce nonlinear music.

There are a variety of uses for adaptive music. Artistic installations are ideal environments for implementing adaptive music. *Dolby Gallery* is an excellent example of what this kind of music is capable of. The *Experiential Audio* system for Dolby Gallery was created by *Waveplant*.

According to their website, “Waveplant created a 100% generative audio experience for the Dolby Gallery, with procedurally generated music based on the color palettes of masterworks from the past century” (Waveplant, n.d.).

Another great use of adaptive music is in video games. Brown and Kerr (2009) elaborate, “these are entirely digital environments that are inherently interactive and involve unpredictable real-time state change” (Background section). Authors mention that adaptive music techniques have been used as early as 1987 by Toshio Iwai in the video game *Otocky* by Famicom.

Frogger by Konami (1981) is believed to be the first video game that applied adaptive music. *Otocky* (1987), *Monkey Island 2: LeChuck’s Revenge* (1991), and *Ultima Underworld: The Stygian Abyss* (1992) are among the earliest video games that employed adaptive music and revolutionized audio systems in video games.

However, the concept of adaptive music is not as new as video games. One of the ancestors of adaptive music was Wolfgang Amadeus Mozart. He designed a waltz game called *Das musikalische Würfelspiele* (the musical dice game) in the 18th century (Jones, 1991; Noguchi, 1996). This game consisted of several short musical phrases and variations. Using pre-composed sequences randomly introduced by rolling the dice, the player could compose a new waltz with each roll (Pichlmair & Kayali, 2007).

Another notable innovation is Modest Mussorgsky's Pictures at an Exhibition. Although it is linear, it explores many parallels to modern film and game music. This work is the story of visiting an art gallery, which virtually simulates the experience of being there through music. Each movement corresponded to a picture in an art gallery, and Promenade sections in between the main movements indicate walking through the exhibition (Young, 2012).

Loops and looping are essential parts of adaptive music. It is an unanswered question if loops in video games are received differently than in popular music (linear). However, Collins (2007) suggested that game audio might have helped looping become more acceptable in popular music by changing how it is received and listened to.

Hutchings and McCormack (2020) argued that adaptive music systems for video games are rich in academic research background. However, translation from research to commercial adoption has been slow.

Interactivity

We described video games as interactive environments. However, an interactive environment is not necessarily affiliated with *interactive music*. Interactive music is different from adaptive music in some aspects, while it shares the same behavior.

Young argued that interactive music refers to music that the user directly interacts with. We can find this in music-based games where user input directly affects a musical performance, like the *Guitar Hero* series (first release 2005). However, adaptive music responds to interaction with the game, not music itself (Hayes, 2011; Young, 2012).

Collins's (2007) argument is different, however. In his definition, interactive audio is the audio that responds to the *player's input*, while adaptive audio responds to the *gameplay* or *playback*

environment – that might be out of the player's control – rather than responding directly to the user (Whitmore, 2003; Fay et al., 2004).

Farnell (2007) provides another definition. He stated that except for the music tracks in some cases that are linear, all game sounds could be considered interactive audio. He believes that the player input makes audio interactive, and adaptive audio is a form of interactive audio "where a complex function or state machine lies between the player's actions and the audible response" (p. 2). Change in the sound in certain situations, such as the presence of a monster or triumph at completing a level, are examples of adaptive music in Farnell's definition.

Importance of Music in Video Games

So far, we have discussed the nature of adaptive music and its characteristics. In this section, I will explain the role of music in video games and its importance.

1. Support a Narrative

Music could affect how people perceive emotions, characters, actions, and interpret the story in a film (Marshall & Cohen, 1988; Prechtl, 2016). Bullerjahn and Güldenring (1994) found that "...film music polarizes the emotional atmosphere and influences the understanding of the plot" (Abstract section). Parke later supported it using mathematical models (Parke et al., 2007).

Although video games take a different approach to music than films (nonlinear vs. linear), they share one crucial role: supporting a narrative (Jorgensen, 2006; Berndt and Hartmann, 2007; Collins, 2008). Today, with the increasing potential for narrative scope in video games, telling a compelling story is more achievable than ever, and music plays an essential role in making it possible (Young, 2012).

2. Immersion

Sanders and Cairns (2010) define *immersion* as below:

> Immersion is the sense of being *in a game* where a person's thoughts, attention and goals are all focused in and around the game as opposed to attending to being concerned with anything else, such as what is going on in the room around them. (p. 1)

"Video game designers and players hope video games could be as *immersive* as possible" (Xiaoqing Fu, 2015, p1). Research showed that video game music influences and increases the player's immersion. Particularly about adaptive music in video games, a study found that adaptive music can significantly increase players' reported experienced feeling of tension (which contributes to immersion), that players recognize and value music, and that players recognize and value adaptive music over linear music (Plut & Pasquier, 2019). Another study showed that the presence of a musical score significantly affects the player's video gaming experience (D. Lipscomb & M. Zehnder, 2004).

3. Guiding the Player

Games that require puzzle-solving skills and patience tend to be complex. The audio in such games plays a critical role in helping the player solve problems and get over challenges they might encounter. The same function will generally apply to different genres of games, such as adventure, simulators, or sports games. However, the audio can play a more limited role in specific genres of games (Collins, 2007).

Compositional Approaches

Due to the nonlinear nature of video games, composers need to consider a different approach compared to film and linear media. They should compose with a mindset that enables the

transformation of music and mood shifts seamlessly. Music change might be influenced by the environment and atmosphere of the scenes, weather, the number of *NPCs* (*non-player characters*, e.g., enemies), winning vs. losing, stealth vs. detection, fighting vs. relaxing, and many other variables (Young, 2012). Breaking down music assets into components enables the game music system to reorganize the music materials with more flexibility and seamless transitions.

Some games like RDR 2 sit somewhere between the world of video games and movies by offering a cinematic experience. It means that in some scenes, the game has fixed duration and linear behavior. Hence, it asks for linear music like movies.

Music in video games adapts to the game state based on *cues* (a signal to start playing a particular audio track). In other words, it works based on conditional statements generally. For example, if the player starts shooting (cue), then add bass and percussion tracks to the music; if the player enters the jungle (cue), then fade into the jungle theme; and so on. Cues are markers on music tracks that serve as transition points, and by composing cues, we mean composing stems for these transition points. There are two general approaches to compose adaptive music for video games: *Vertical and horizontal mixing* and *procedural music*. I will explain each approach in order.

1. Vertical and Horizontal Mixing

Sequencing enables musicians to create a highly customizable workspace for music production. Today, most music genres like pop, hip-hop, and rock use the sequencing method in production. In sequencing, stems consist of short recorded clips of individual instruments, vocal lines, and sound effects, layered together and stored as audio or *MIDI* data in a sequencer program like a DAW. MIDI is a technical standard for playing, editing, and creating music using computers, digital interfaces, or electronic instruments like synthesizers. Then, the sequencer allows the

composer/producer to rearrange those recorded clips with high flexibility and create a full-length track. Sequencing stands between adaptive and recorded audio (Farnell, 2007).

The same method has found its way into video game music. The dynamic layering of music parts has become common in games (Hutchings & McCormack, 2020). With changes in the environment, player actions, and the number of NPCs, layers of music can be added or dropped, or the length of music can be modified by repeating and using variations. As explained earlier, these layers can be triggered to play according to specific events (cues).

Sequencing is a general term. To clarify, I explain vertical and horizontal mixing as a compositional approach (Young, 2012; Nuanáin, 2019). Vertical mixing is adding or removing layers of music that are playing *simultaneously*. It allows for adjusting different levels of dynamic and emotion in the music, for example, adding bass and percussion lines for more excitement. Vertical mixing usually requires stems to be compatible, in sync rhythmically, and in harmony with each other; to sound good when played together.

Horizontal mixing is the way stems are arranged following each other. Stems of each layer or a group of compatible layers can be *repeated* in the form of a loop or *shifted* to other themes, variations, and musical sections by changing and branching stems at any time and order *seamlessly*, without being noticed by the player. Sometimes transitions are made possible using short musical sentences that connect different sections, and sometimes, using *crossfades* (fading out of one piece while another piece fades in at the same time). Making seamless transitions is a challenge in adaptive music production which I will discuss further.

By combining vertical and horizontal mixing, we can produce “an extended, dynamic arrangement of ever-changing music from a very small set of elements” (Nuanáin, 2019, para. 13). Most games use a combined approach (Young, 2012). One of the most effective uses of vertical and horizontal mixing has been in Rockstar Games’ *Red Dead Redemption* (*RDR*)

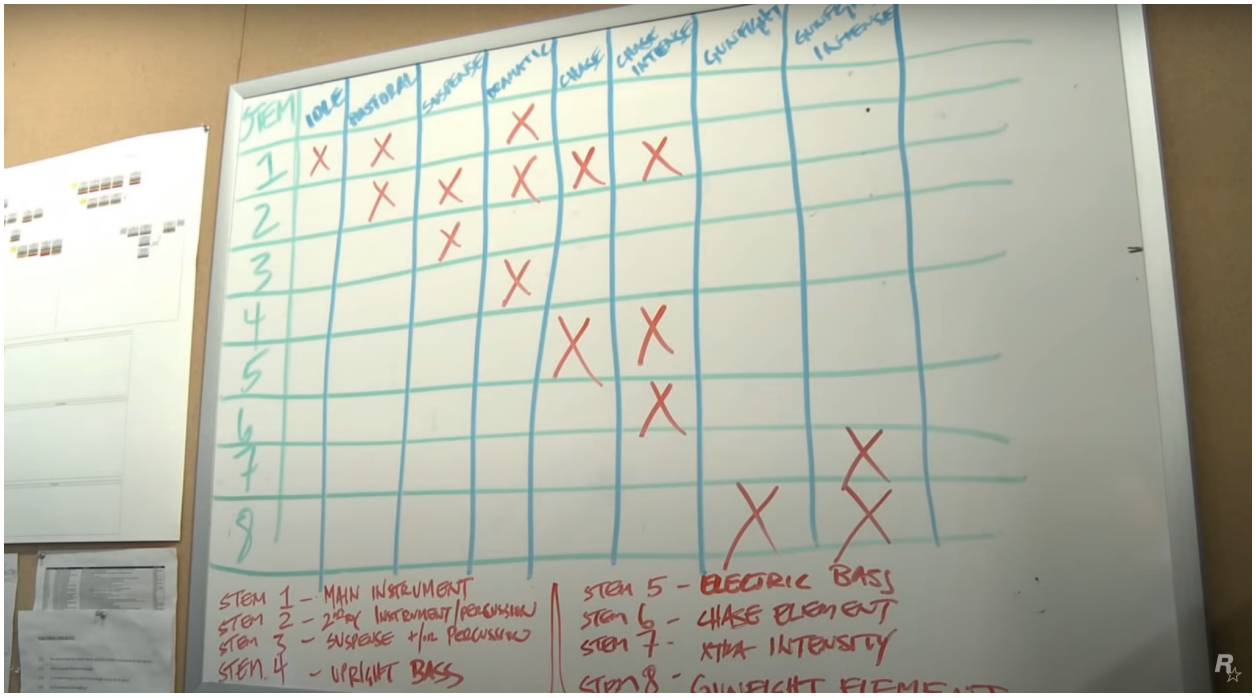
series (first release 2010) soundtrack, composed by Woody Jackson and Bill Elm for RDR (2010) and Woody Jackson and Daniel Lanois for RDR 2 (2018) (Hutchings & McCormack, 2020**).** Jackson and Lanois's work for RDR 2 won *The Game Awards* (2018) for *Best Score and Music*. The soundtrack is highly adaptable, which makes an immersive gaming experience. RDR's music is notable for *the detailed layering of stems* that accompany the player in diverse circumstances.

A behind-the-scenes video of RDR's soundtrack (Rockstar Games Australia & New Zealand, 2010) explained:

> The biggest challenge was finding a way to record the score that could adapt according to the decisions the player makes. So instead of songs, the composed stems – The team decided to create all the music at 130 beats per minute in A minor so that the game engine can play stems on top of one another and create music on the fly.

Figure 1

Table of stems for RDR 2's soundtrack (Rockstar Games Australia & New Zealand, 2010)



"If you jump on a horse, a bass line kicks in. When you start getting chased, timpani rolls in and big fuzz guitars roll in. When there's a shoot out, the music actually changes with the action," Ivan Pavlovich, the music supervisor at Rockstar Games, explained in the video.

The advantage of vertical and horizontal mixing over procedural music is that it allows using real instruments and creating thoughtful compositions. It is crucial to mention that in the vertical and horizontal mixing approach for making adaptive music, a machine, a computer, undertakes the responsibility of *reorganizing* stems according to *predefined rules*. It means that adaptive music produced using vertical and horizontal mixing is *assisted* by the machine but *not generated* by the machine.

2. Procedural Music

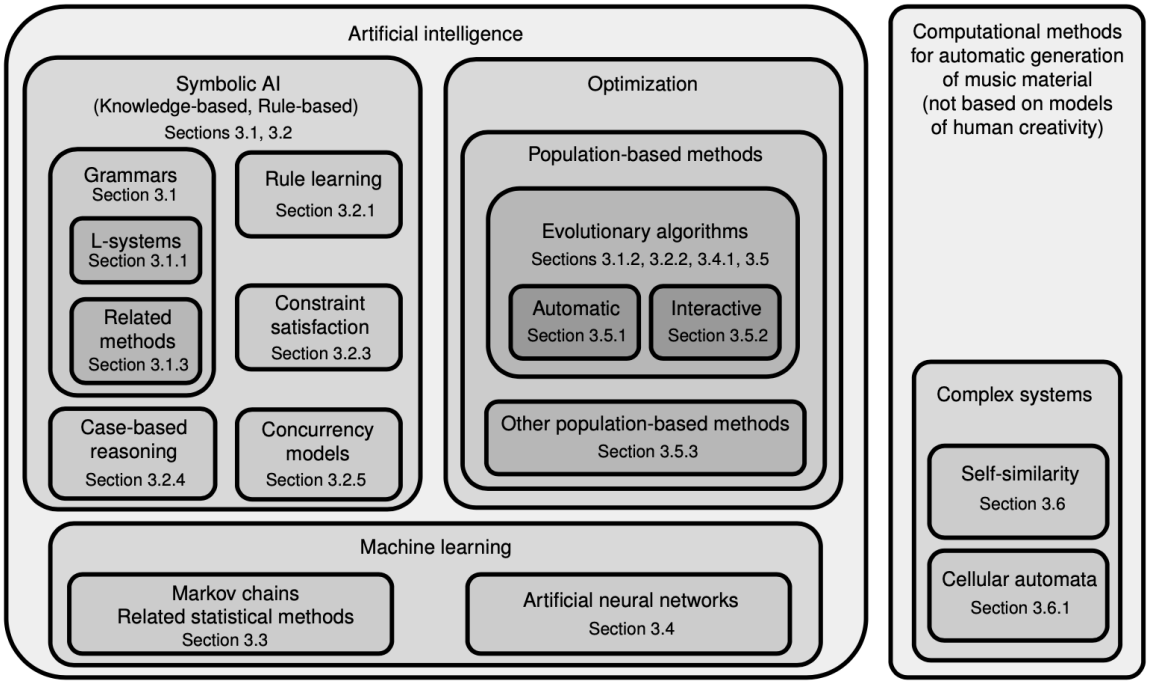
Farnell (2007) defines *procedural audio* as a form of nonlinear audio generated in real-time according to a set of “programmatic rules and live input” (p. 1). He sees procedural music as “sound qua process, as opposed to sound qua product.” Procedural music often sounds synthetic. In other words, procedural music is all *generated and handled by a machine*, as opposed to the vertical and horizontal mixing approach, which is *composed by a human* and only *assisted by a machine*.

Procedural music has been used in video games. The purpose of procedural music is to avoid music from sounding repetitive when listened to many times. Very few projects have enough budget to create algorithms for procedural music. Also, current algorithms are less appealing aesthetically than composed music used either in linear music or vertical and horizontal mixing (Adam, 2014). Some video games may apply a combination of vertical and horizontal mixing and procedural music approach to managing composed music and real-time generated music to adapt to the game.

Fernandez and Vico (2013) suggested a model for algorithmic compositional systems that classify them in four general categories as shown in Figure 2:

Figure 2

Procedural music generation methods (Fernandez & Vico, 2013)



Molina (2020) described the four categories of this model as below:

> (a) *Symbolic AI*, whose main representatives in algorithmic composition are grammars and rule-based systems. They have been used both for imitating musical styles or specific composers and for automating the composition process. These are usually very labor-intensive methods, since they require the musical knowledge to be encoded and maintained in the symbolic framework.
>
> (b) *Machine learning*, comprising Markov chains and artificial neural networks, whose nature have made them generally more suitable for imitation purposes.

(c) *Optimization* techniques, having been used for imitation and for the automation of compositional tasks, and counting on the evolutionary algorithms as the most representative example.

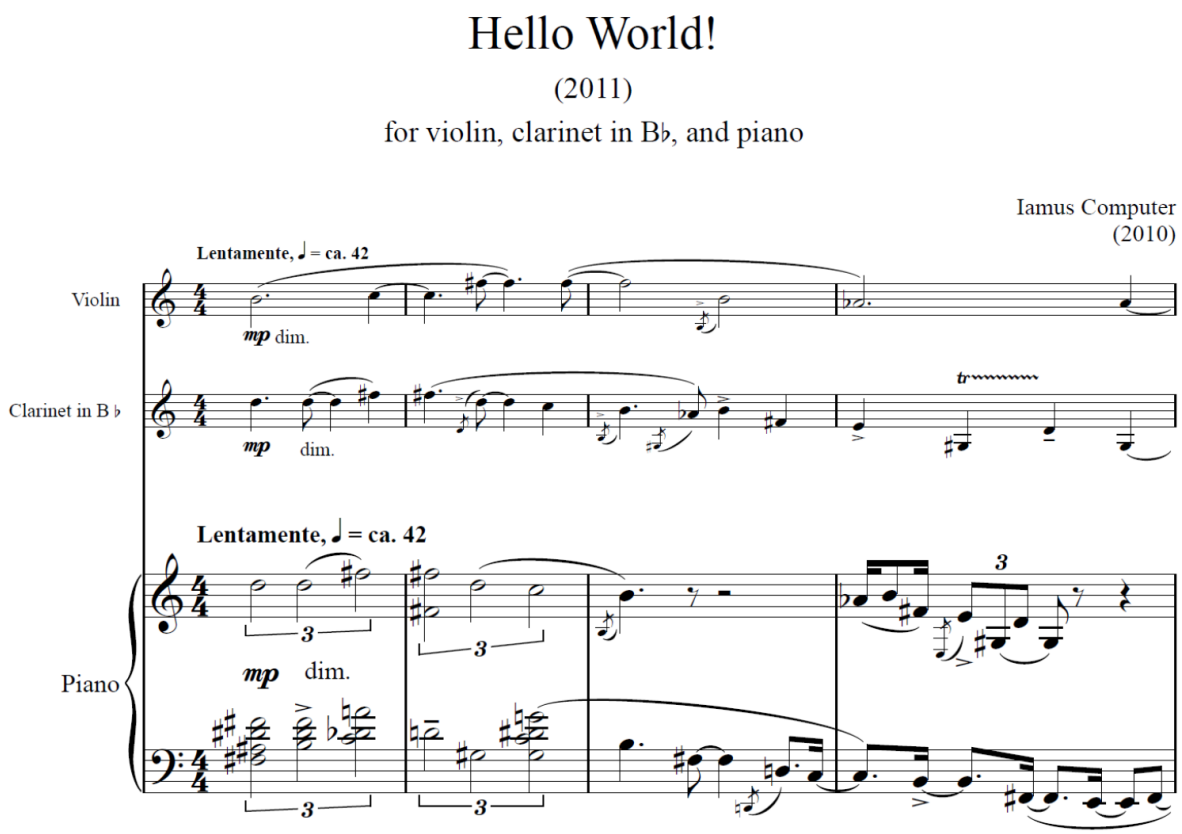
(d) *Complex-systems* like self-similarity and cellular automata, used to generate novel material without being restricted to human knowledge. (pp. 7-8)

Molina's research led to the creation of an algorithmic composition method called *Melomics*. It is a bioinspired compositional system based on evolutionary search, "with a genetic encoding of the solutions that are interpreted in a complex developmental process that leads to music in standard formats" (p. vii).

This system has exhibited a highly creative power and is capable of generating versatile types of music. Molina (2020) claims that the music generated by Melomics has proven to be indistinguishable from composing music on many occasions.

Figure 3

"Hello World!", The first piece of full-scale work composed entirely by computer music using notation (Molina, 2020)



The computer cluster *Iamus15* was programmed to run Melomics software for about ten hours to create a composition for clarinet, violin, and piano in contemporary classical style, called *Hello World!* (2011). Molina (2020) claims this piece is "arguably the first full-scale work entirely composed by a computer and using conventional music notation" (p. 54).

Adam and his team designed a procedural music generator for JavaScript-based web games called *AUD.js*. This system can generate music in real-time to adapt to the game state based on input parameters (Adam, 2014). In the A/B testing of this music generation system, they found

that although AUD.js provides “reasonably effective music for games, adaptiveness of this (generated) music does not necessarily improve player’s experience over composed music” (p. iv).

He also found that the AUD.js might be useful for game music integration under time pressure. An application of such a system could be making demos or *temporary music* (*temp music*) for in-development games. However, Hans Zimmer (2017) advises avoiding using temp music.

Adaptive Audio Middleware

Since adaptive music is constantly changing in the game and needs to be modified in real-time according to predefined rules, it requires a system to manage this process and create a bridge between the audio system and the game system. Such a system is called *audio middleware*.

An early example of adaptive music middleware is the *iMUSE* engine. Composers Michael Land and Peter McConnell developed the iMUSE system in the 1990s for video games when they worked at LucasArts (Land & Mcconnell, 1994; Brown, Kerr, 2009). This engine let them smoothly transition through variations on themes depending on different game scenarios. *The Secret of Monkey Island* (1990) is well-known for its adaptive music, handled by iMUSE (Nuanáin, 2019).

Today, *FMOD*, developed by Firelight Technologies, and *Wwise*, developed by Audiokinetic, are the two most popular audio middleware platforms used in hundreds of games, including many *AAA* games (games with large production and marketing scale) across the video game industry (*FMOD Games*, n.d.; *Wwise in Games*, n.d.).

Some video game companies develop their exclusive middleware platform or integrate it within their game engine. Rockstar Games uses its home-developed *RAGE* engine (*Rockstar Advanced Game Engine*) to develop open-world games like RDR series. Some developers

create an adaptive music engine exclusively for one game by manually coding it into the game. A good example is the Gorogoa soundtrack integrated into the game by the composer Joel Corelitz. I will discuss the Gorogoa soundtrack in further sections.

Challenges

Nonlinear audio in video games causes composers and sound designers to face new challenges. Because with game audio, “there are new consumption modes, new production modes, and new listening modes” (Collins, 2007, p. 10).

Unpredictability

Unpredictability has been the greatest challenge of game composers since the advent of video games. The nonlinearity of games asks for nonlinear music, which requires a unique approach for each game. “The main problem of game music at a very fundamental level has been how to make a typically linear art form such as music fit into the nonlinear environment of video games” (Young, 2012, p. 8).

As explained earlier in the vertical and horizontal mixing approach, creating stems and using loops has been the most common solution to this issue. *Space Invaders* (1978), *Asteroids* (1979), and *Dig Dug* (1982) are some of the earliest games that utilized loops (Young, 2012).

The Length of Gameplay

Due to the nonlinear nature of video games, the length of gameplay is indeterminate. A player may complete a level quickly, and another player may get stuck for hours (Collins, 2007). This problem makes it difficult for the composer to figure out how to organize stems, how many tracks, and how many minutes/hours of music are required. The composer cannot compose an infinite number of cues. The solution is to “re-use cues in other areas of a game, to reduce the

number of unique cues needed, but without creating a repetitive sounding score" (Collins, 2007, p. 7). This problem might result in less dramatic pieces that are less memorable. The other approach is to use looping more often, which might cause "*listener fatigue*":

> Games are designed to be played multiple times, and repeated listening can be tiring, especially if a player spends a long time on one particular area of the game. Games have begun to incorporate timings into the cues, so that if the player does get stuck on a level, the music will not loop endlessly, but will instead fade out. (p. 7)

Fading out has been a solution to avoid listener fatigue (Collins, 2007). Composer Marty O'Donnell elaborated on the *Halo: Combat Evolved* score (Bungie Software 2001):

> There is this "bored now" switch, which is, "If you haven't reached the part where you're supposed to go into the alternative piece, and five minutes have gone by, just have a nice fadeout." (Battino & Richards, 2005, p. 195)

Eric Barone, developer and composer of the role-playing simulation game *Stardew Valley* (ConcernedApe, 2016), has treated the soundtrack the same way.

Composition

Most music we hear uses tonal harmony. Since tonal arrangements heavily rely on harmony rules, creating harmonically compatible stems is a compositional challenge. The stems also should be in sync rhythmically. The result of these limitations is that music changes are only possible at specific points in the playback. With the progress made in technology that enabled the machine to generate music, machines also faced the same problem. Melomics's algorithm (introduced in the Procedural Music section) can generate tonal and atonal arrangements (Molina, 2020).

Transitions

Scoring unpredictable elements could be very difficult for composers. When the game state changes and requires the music to adapt to the new state, the transition should take place smoothly to contribute to the continuity and immersion of gameplay. Composing some cues might be difficult, especially when the environment or atmosphere change and need a completely different theme. In such cases, seamlessly connecting two tracks is a challenge. There are several approaches to make smooth transitions. Collins (2007, p. 5) has introduced five types of transitions:

1. Cutting

Early games tended towards direct splicing and abrupt cutting between cues, though this can feel very jarring for the player (this was especially common in *8* and *16-bit games*).

2. Fading

The most common transition is to fade out quickly, and then begin the new cue, or to crossfade the two cues, which is to say, fade one out as the other cue fades in. Nevertheless, the transition can still feel abrupt, depending on the cues or the speed of the cross-fade.

3. Stinger

Another common type of transition is to use a quick *stinger*, also known as a *stab* (a quick *shock chord*). Particularly as one of the most abrupt transitions is to that of violent combat, the stinger—combined with the sound effects of violence (gunfire, sword clashes, etc.)—will obscure any disjointed musical effects that may occur.

4. Cue-to-cue Transitions

There are also a few more recent attempts at transitions that are more effective, but which are far more demanding on the composer, who must think of the music in nonlinear and non-traditional ways. For instance, some games use *cue-to-cue* transitions, so that when a new cue is requested, the current sequence plays until the next marker point, before triggering the new cue.

5. Layering

Further methods of transitions include layering approaches to song construction, in which music is composed in instrument layers with the understanding that at any time various instruments may be dropped and others may be added. This works well with some transitions, but again, it can be difficult to move quickly from cue to cue in a dramatic change.

Technical Difficulties

Adaptive music is achieved through a combination of compositional foresight and careful integration. Handling technical aspects of integrating music into the game has been a challenge from the beginning. At the beginning of the video games era, technology was a barrier to integrating music. Limited audio capabilities of game systems limited composers' framework. Later, composers had more freedom with the improvement of sound chips and the ability to play CD-quality music on gaming consoles.

Today, game systems have achieved remarkable audio features. They support *Surround* sound (e.g., *Sony PlayStation 5 3D Audio*), *real-time mixing*, and *multichannel* support (Young, 2012). In addition to supporting complex, high-quality sound, we have the audio middleware today. Technical difficulties still exist today, but technology is not a barrier anymore. It is about finding

an appropriate solution, an *audio strategy* that fits the game the most. I would say dealing with music integration difficulties requires composers with an engineering mindset.

The Mix

The relationship between different kinds of sounds in a video game is a matter of *mix*. Stockburger (2006) identified five types of sound objects in the game space, and Collins (2007) briefly explained each as follows:

> Speech (dialogue), zone (ambience), score (music), effects (diegetic game sounds) and "interface sound objects" (nearly exclusive to menu screens, sounds generally "not perceived as belonging to the diegetic part of the game environment"). (p. 6)

Each of these sound categories has a dedicated *frequency range* unique to the game. Composers and sound designers should consider the possibility of overlapping frequencies in their mix. Collins (2007) elaborated, "since dialogue and the sound effects of, for instance, combat, are all mid-range, there is a constant risk of creating a 'muddy' sound if the music also contains a lot of mid-range activity" (p. 6).

Although today's game audio systems are capable of real-time mixing, it is still hard to implement due to technical difficulties and its expenses. Therefore, many game developers cannot afford such a system or handle it technically, and real-time mixing is mainly seen in AAA games. Hence, some games should be scored with potential mixing problems in mind. Anahid Kassabian has touched on another important point regarding the mix. In Kassabian's (2003) discussion of "evaporating segregation of sound, noise, and music," she suggested that the soundscape of games has impacted recent film scores and the distinction between sound design/sound effects and the music is significantly decreased. The blending of soundscape and

music (i.e., combining non-musical sounds with music) makes it more challenging to mix sounds properly (Collins, 2007).

Expressiveness

The actual performance of music differs from the notation. Musicians add deviations and nuances in pitch (e.g., *vibration*), timing, dynamics, and other musical parameters. Their artistic touch makes the music sound alive and expressive. *Expressiveness* is necessary for music to sound natural (Fernandez, Vico, 2013). Although composing music with machines as an imitation problem has been solved with high success (Cope, 1992; Pachet, 2002), the lack of creative input and expressiveness are still challenges for generating music with the computer (Gero J. S., 2000; Pearce & Wiggins, 2001; Ritchie, 2007; Boden, 2009; Molina, 2020).

Interfering with Other Players

Gaming experience and the adaptive music produced as a result of the gameplay are unique to the player. What happens when there is more than one player at the same time? How will the audio system respond (Selfon, 2006; Collins, 2007)? This problem could be even more challenging if the *multiplayer* mode is in a *co-op split screen* where the two players play on the same gaming console or personal computer (PC).

Methodology

Overview

In this study, I will use the *research-creation* method (Chapman & Sawchuk, 2012). This method is widely chosen for studies that address creative work, including artistic or experimental aesthetic components.

While research-creation is an emerging method, it is not new, but it has gotten more recognition in recent years. The reason is that it meets the needs of today's research topics with the rise of digital media and digital humanities. Such studies engage in creative practice such as producing video, audio, and interactive media like video games and blogs. Therefore, we need to approach them properly, which might not be possible with traditional scholarly methods.

According to Ludwig Wittgenstein's (2009) insights on the concept of research-creation, research-creation explores four criteria: *Research-for-creation*, *research-from-creation*, *creative presentations of research*, and *creation-as-research*.

Gathering information and material to assist the creation is research. Therefore, it is a form of research-creation method called research-for-creation. On the other hand, creation is a way to generate research data. Hence, we call it research-from-creation. Creative presentation of traditional academic research in a creative way is also a subcategory of the research-creation method. Finally, there is creation-as-research, which means creation is required for the study to emerge. This study applied all these four approaches to present comprehensive research in the field of adaptive music.

Implementation

The literature review covered three main topics that are the building blocks of this research: Music terminology, storytelling with music, and adaptive music in video games. In the following sections, I have conducted the creative section of the research in two parts, as explained below.

1. Case Study: Gorogoa

First, I reviewed the soundtrack of Gorogoa as one of the most creative, ambitious projects in video game music to understand how its music system works. Then, I interviewed its composer, Joel Corelitz, a member of the research committee in this study, to better understand his approach to composing adaptive music.

In this part, I discover, introduce and explore several important topics, including audio strategy, compatible loops, player-as-composer concept, and the relationship between adaptive music and soundscape.

2. Creation

In the second part, I composed adaptive music based on what I learned from Corelitz's work (compatible loops) and elaborated on the compositional approach and its applications. Finally, I presented my findings in an explainer video. Creative materials, including sheet music (Figure 6) and the video explainer, are appropriately cited.

Case Study: Gorogoa

Review: The Soundtrack of Gorogoa

Gorogoa is a puzzle game developed by Jason Roberts and published by *Annapurna Interactive* in 2017 for Nintendo Switch, Xbox One, PlayStation 4, Windows, Mac, iOS, and Android. The game development took nearly six years to complete. The game is an interactive story within four tiles placed in a two-by-two grid. Gorogoa is about the life of a boy who lives in an imaginary world. During the game, the boy encounters the monster of Gorogoa, faces war and poverty, grows old, and reflects on his past.

The beautifully hand-drawn design conveys pure feelings, and the contrast between cartoonish design and its deep story doubles the impact. It consists of various unique puzzles that the player should solve by clicking on objects and moving the tiles. Each tile contributes to a part of each level story. While a tile might present a completely different environment, they all work in conjunction towards one goal and are closely related.

When I started playing Gorogoa, I expected some dialogues or instructions. However, there were not any. The game was self-explanatory, and every element was carefully designed to guide the player implicitly. It took about three hours to finish the game. It was a short but meaningful experience, and I do not call it a video game. I would call it an experience, a work of art.

Story

The boy sees a majestic creature (often called the Gorogoa monster) from the window of his room – that probably resembles a goddess and becomes curious. It seems he wants to communicate with the monster. He goes on an adventure to gather five magical elements that

the monster asks for. After successfully achieving them, the monster denies the gift because he achieved them effortlessly. The monster gets mad and pushes the boy off the tower and destroys his beautiful city, which makes the player recognize the boy was responsible for all the ruins the player saw before in the gameplay.

The player plays the past and future of the boy, goes back and forth in time, and faces the bitter reality of poverty and war; or as Rad (2018) wrote in IGN, “Gorogoa explores the nature of spirituality, myth, and history with a wordless elegance” (para. 4). When the boy falls, his leg breaks, and he has to continue the journey by studying and revelation until he gets old. Then he recalls his past and obtains those five precious elements by wisdom, and finally, finds redemption.

Sound Effects

It was 3 am when I was playing. It was cold and raining, and I could hear the sound of raindrops hitting the window. The soundtrack caught me when the boy was in a dark room, trying to solve the mystery. Dark ambient music began to play, and suddenly the thunder and lightning struck in the game. That was when I realized something terrible is going to happen to this boy. The strike was not random. It was there intentionally and purposefully. The sound effects and music were blended to build a unique atmosphere and carry the visually untold parts of the story.

Jason Roberts did all the production on his own except for the sound design. Eduardo Ortiz Frau designed the sound effects. According to Kohler’s (2017) review published on Kotaku, the sound design is “‘all real sounds,’ natural noises drawn from real life.” I believe this is one of the reasons that the game feels so genuine. Maybe that is why the effect is everlasting. The game world might be imaginary, but it sounds real.

Soundtrack

Joel Corelitz composed the original soundtrack of Gorogoa. Corelitz is a composer & sound designer best known for his work in video games. He has been involved in several titles as composer/sound designer, including *Eastward* (2021), *Halo Infinite* (due for release in 2021), *Death Stranding* (2019), *TumbleSeed* (2017), and *The Unfinished Swan* (2012). In 2018, he composed the soundtrack and developed the audio strategy for Gorogoa, which was an ambitious project and is the subject of this study. Corelitz was a member of the research committee in this study and contributed by providing feedback on the soundtrack review and accuracy and validity and sharing his knowledge and experience in the interview section.

Part of the reason he stands out is his interest in sound design and “fusing music and sound design into a unified audio experience centered around texture and mood” (Joel Corelitz, n.d., p. about). Corelitz also runs *Waveplant* (Waveplant, n.d.), an audio consulting agency focused on immersive audio and sonic branding. The studio specializes in designing the audio strategy and creating soundscapes and music for products, events, installations, and experiences.

Corelitz designed the audio strategy to make all sonic elements match the game atmosphere and its four-tile gameplay system. The main goal was to “create music for Gorogoa that fit together the way the puzzles did, separate compositions that could blend into a harmonious whole” (Kohler, 2017).

The soundtrack is basically electronic ambient music. However, it is not background noise. It is purposefully composed in a way to convey the feeling of each environment within every tile. Therefore, every time the player enters a new environment inside each tile, the music changes smoothly to match the atmosphere.

Since every tile tells part of the story, the soundtrack contributes to the storytelling while going back and forth in the tiles. For example, when the player goes to places like the ruined city, the music becomes sad or scary, and when the player goes to mountains to achieve one of the magical elements, the music becomes motivating and uplifting to show resilience.

When the player moves forward in each level, the soundtrack intelligently guides them to let them know if they are in the right direction or not. As the player gets closer to solving the puzzle, the music goes higher.

In addition to ambient music, Corelitz has applied melodic phrases as musical guiding elements. Therefore, the soundtrack and sound effects act like the gameplay instructions. For example, the player will hear an epic melody in the level with ancient walls, which is crucial to solving the puzzle. This melody lets the player know they are on the right path.

Some players might need to look back and recheck everything to solve the puzzle. When the player goes back, the soundtrack changes to what it was before. The beauty of the soundtrack is that it does not matter how many times and how quickly the player goes back and forth. Every time it adapts to the environment smoothly without breaking the flow of the music.

Corelitz designed a thoughtful structure for this flawless music system. His work was inspired by a musical project called *In B Flat* (Solomon, n.d.):

> The first thing I thought of was… a website called In B Flat. It's a grid of 20 YouTube videos, you can play one of them, you can play all 20 of them—any amount from one to 20 and they all work together, no matter when you start them and when you end them. (Kohler, 2017)

Roberts and Corelitz worked together to design the game and audio engine in a way that would work similarly. In Kohler's (2017) report, Corelitz said:

> The composite score that you hear as a player is the product of whatever the four tiles are that are on the screen. – The only way to hear the score is to play the game. The game itself is the presentation engine for the score, and it's not something that you can listen to the same way every time.

The structure of the game enabled him to treat it like a loop machine. He created loops that are always compatible (Waveplant, 2020), and the music you hear is unique to how you arrange the tiles and objects inside them. In a way, *the player is the composer* of the soundtrack. There are four tiles, and there are one or several clickable items inside each tile. The tiles and items inside them act like loop pads that mix and match once the player clicks on them. The player can try out different combinations by exploring the game and hear different sets of music every time plays Gorogoa.

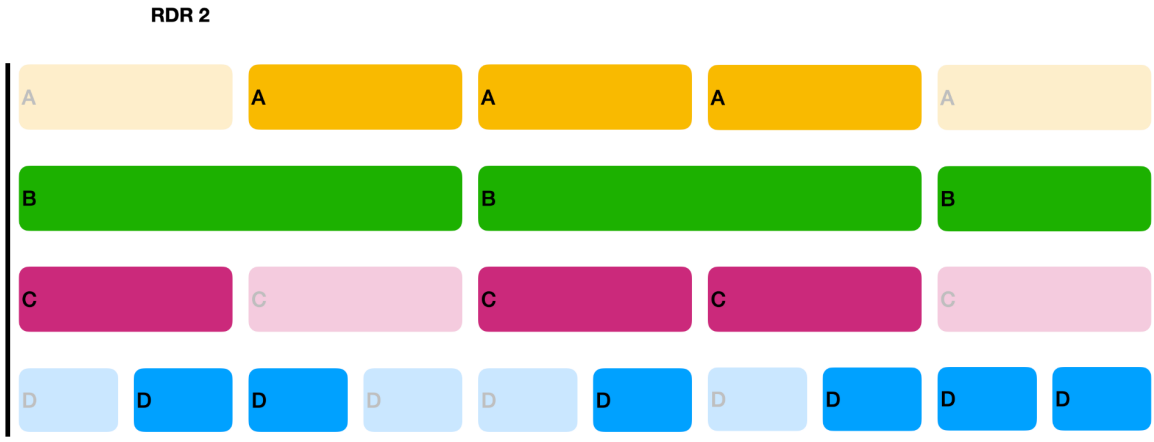
Although the soundtrack becomes predictable in such scenes, it is interesting that the music is always ready to adapt, add new lines and play melodic phrases. These musical phrases can be played at any moment without disrupting the harmony, and they are amazingly compatible with each other. This game is a *loop machine* that anyone can play.

Loops are an essential part of such a structure, and Corelitz took advantage of them to keep the music playing. This is especially obvious when the player plays parts of the game that have melodic phrases. The melodic phrases keep repeating like a tape because they are fixed recorded audio tracks playing repeatedly.

It is needless to say that Corelitz has used vertical and horizontal mixing to reorganize the stems during the gameplay. Using compatible loops enabled him to overcome the compositional challenge of harmony and rhythm. The stems are always compatible and can be modified anytime.

Figure 4

A hypothetical visual representation of stems for RDR 2 soundtrack

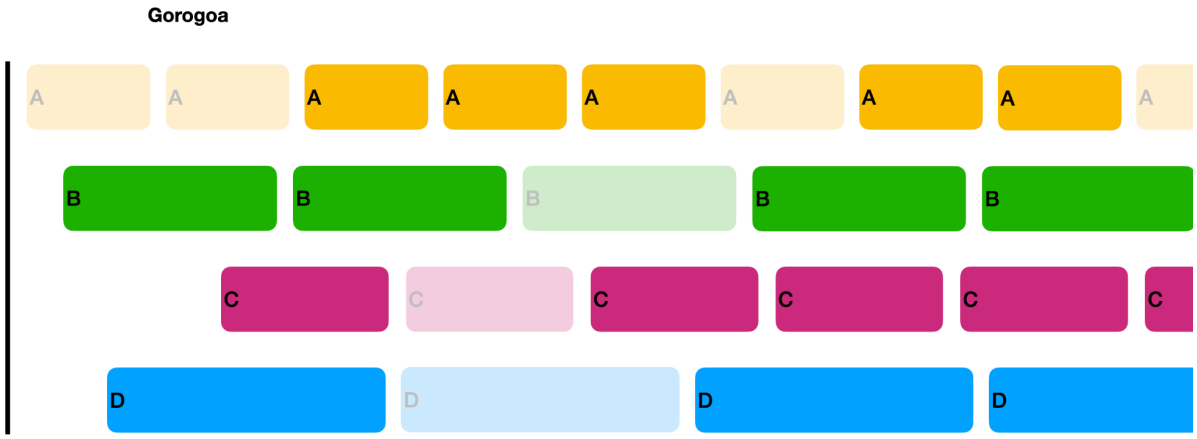


Note. Stems with dim colors are disabled and cannot be heard; shown to present the placement of stems locked to specific points in the music timeline.

To give you an idea of how dynamic this approach is, look at these music lines. This is how music works in RDR 2. Woody Jackson adds or drops specific layers of music (stems) or instruments at certain points using loops. This approach is excellent for making *melodic music*. Nevertheless, since the lines should be rhythmically and harmonically in sync, loops can be added only at specific points.

Figure 5

A hypothetical visual representation of stems for Gorogoa soundtrack



Note. Stems with dim colors are disabled and cannot be heard; shown to present the placement of stems that can be positioned anywhere in the music timeline.

With Corelitz's approach inspired by the In B Flat project, any music component can be added at any point. The great thing about this approach is that the music can be played for a long time without becoming repetitive because it takes a very long time for the loops to get back to the same point where they started together in the beginning, and the piece is constantly changing. This is perfect for creating *ambient music* or *sound atmospheres*.

Another thing that I noticed is that Gorogoa does not have a specific melody. I cannot remember and sing its tune. However, Corelitz has created a musical atmosphere, a *sound world* that I recognize. It is a soundscape. This made me think about great opportunities for the gamification of music in urban environments as a soundscape.

I discussed the use of adaptive music beyond video games with my dear friend, Rouzbeh Esfandarmaz, composer, multi-instrumentalist, and record producer. He said, “by implementing adaptive music in real settings, you are not playing a video game anymore; you are actually in the game.” He is fascinated by the use of adaptive music in fear conditions, like a theme park where the interaction/communication between the person and environment is only through light and sound, and the environment responds and possibly transforms in reaction to the person’s actions. Esfandarmaz believes that experiencing sound in real settings with open audio systems feels different from headphones because “sound is wave and we hear with our whole body, not with only ears” (Esfandarmaz, personal communication, July 23, 2021).

Since music and sound are universal languages, applying adaptive music in urban areas as a soundscape can also provide accessibility for disabled people. For example, imagine a blind person enters the bank. The music of the bank adapts to the number of people in the line. The blind person can realize if the line is short or long by listening to the bank tune.

Interview with Joel Corelitz

During studying the Gorogoa soundtrack, I ran into the term *audio strategy* several times. Corelitz specifically used this term to explain his approach to the Gorogoa soundtrack. I was curious to know more about audio strategy and ask him about the meaning of audio strategy and his approach in composing adaptive music for video games. The following interview was conducted virtually on August 2, 2021 (personal communication). I had prepared a list of questions. However, I went with the interview flow and asked additional questions that provided a deeper understanding of adaptive music and composing for video games. Each question has been indicated with a number.

The Interview

1- To understand audio strategy, I asked Joel Corelitz, “what is an audio strategy, and how do you prepare one?”

> It’s really just listening to the audio needs of the project because no two projects are the same. It’s really about listening to the developer, talking about the game – if it’s for a game, and then figuring out what kind of and how audio is going to work. For a pixel art game, you could do looping. That’s all you need, usually. So audio strategy is how music is going to live in your experience; what do you need, how many pieces do you need, how long do they need to be? Of course, there are all the creative components like what’s going to be the right fit. But audio strategy really is primarily more of a technical [aspect]; what are the needs of this project, and what does it look like? How is it going to live in the product?

2- There has been confusion over the alternative names of adaptive music. I asked Corelitz for more clarification. “Is it adaptive music, procedural music, interactive, or dynamic? Which one is it?”

> I think those probably mean different things. Procedural is something generated in real-time by the game. I think adaptive is a good general term because it suggests there's no set way to evolve.

3- I became curious to know his definition of adaptive music since he mentioned it is a good general term. “To define adaptive music on Waveplant website, it says ‘it is the kind of music that you will never hear the same thing twice’ (Waveplant, n.d.). I want to know your definition of adaptive music.”

> My definition, well, it's kind of loose. I mean, it just means that the presentation is never the same. There's going to be common sounds, and there might even be common loops, but they're never going to be presented exactly the same way. Gorogoa is a good example; you're going to hear all the same music on a playthrough, you're never going to hear quite the same combination of when pieces stop and start because it's all dependent on what the player does. So that's how I would define it. The presentation is always different.

4- We discussed how important is the role of story and its connection with music in video games. I asked Corelitz's opinion on telling stories with music in video games. "In my research, I am working on how to use adaptive music as a narrative in video games. I would like to know how you use it as a narrative to tell stories with music. Because it is so technical at some points, and it needs to also serve as a narrative. How do you make a balance, and how do you tell stories with this kind of music?"

I don't know that I would always use it as a storytelling device necessarily. I don't think it's the wrong conclusion to draw, but for me, it's all related to the sort of what I've called the strategy. To me, it's not really as much about storytelling as it is about whether there is a need to be. If I talk to a developer about a game and there's a need for the game to present audio in a way that's not linear, then we'll generally kind of come up with some kind of adaptive model. Most of the way we listen to music, like songs or pieces of music or symphonies, has a beginning, a middle, and an end, and adaptive music doesn't. So I think if there's a need to.

This is probably a long-winded answer, but I'm just kind of thinking out loud, if you have a story that's always the same length, you don't need adaptive music. If you have a story or a narrative or a passage in a game that could be one minute or like two hours and you don't know how long it's going to be, then you generally do need some kind of adaptive music to help. Your first playthrough of Gorogoa will be like two or three hours, and then, once you solve all the puzzles, you can go through it again in fifteen minutes. That's how I would put it in terms of storytelling if there's a story that maybe could differ in length and you want to keep that experience interesting.

For me, it's a technical decision that you make. It's always based on the needs of the game. I don't do adaptive music or any kind of nonlinear presentation unless there's a need to. Even a lot of the pieces in Halo just loop. Most of this stuff gets handled on a big game by the audio team, so they'll take like a two or three-minute piece, and they'll and their edit their editorial team will turn it into something that can be extended. It all fits into what I call audio strategy, which is how does this music live in the game? It's the best answer I can come up with right now. It's so hard to define because it's never the same.

5- As Corelitz mentioned Halo, I commented on the soundtrack of the latest version of the game Halo Infinite. “Speaking of Halo, I have listened to the released tracks of Halo Infinite so far, and they sound great. The interesting thing about them is that they are so new and refreshing while loyal to the original theme.”

> Yes, there's a lot of thematic material used throughout that score based on previous ones. It wouldn't be Halo without those themes, and I can only take credit, obviously, for some of the music because there were three composers involved and then another composer on the multiplayer.

6- Composing is a personal process. I asked Corelitz to share his experience about how working with other composers is. “How is working with other composers on the same project? Does your job interfere with each other?”

> We have some contact during recording sessions, but we're not collaborating necessarily. The reason why any project would bring in multiple composers is they just have too much music for one composer. I think they'll assign each of us certain pieces that are kind of more in our voice. It was great, but it was not like we were collaborating. We were all kind of working on different pieces of the same thing. Our job really is to listen to the music supervisor. We're kind of each in our lane and working independently on the same thing.

7- To know his opinion about the role of music in immersion, I asked, "how do you think adaptive music affects the player's experience in the game?"

> I think it's really about if the music needs to feel like a living system within the game. I think it can make the music feel more alive, and it can make it feel more tied to the gameplay. Sometimes adaptive music is actually not the right thing to do. If adaptive music or whatever implementation-like scheme that you pick for a game is too

dependent on gameplay, it can start to feel like you're puppeteering the score and that it and it actually starts to work against you, it starts to be distracting. I think a good model for adaptive music or music that evolves sort of intelligently with the game is that it kind of has to feel like it's doing it. It can't be too touchy, like it can't be super reactive. You gotta be careful with it.

It also adds a whole other layer of implementation. It's like does the developer have time to do that? Sometimes I find that just writing a good piece of music is better than coming up with an adaptive model. You have to know when to use it. Gorogoa was a great case for it; a stealth game is a good case for it. It's a tool that definitely has its place, but you don't want to start putting it everywhere.

8- I asked him to elaborate more on the role of the composer in music implementation. “Are you suggesting that the implementation is the job of the composer?”

Sometimes it is, sometimes it isn’t. For most games that I’ve worked on, it isn’t something that I’ve handled. Gorogoa was an exception. I have enough of a coding vocabulary and enough technical sensibility that I can pick up how to use a scripting engine pretty easily. I’m not like an FMOD or Wwise expert by any means, but I can open a session and figure out what’s going on and figure out how to add stuff to it. I didn’t implement it for the first time. FMOD developers figured out how to do it, and then they just taught me how to do it. To me, especially on an indie project, it’s very often sort of like a shared job.

9- Since Gorogoa uses musical soundscapes, I asked Corelitz about the relationship between music and soundscape. “What do you think about the connection of music and soundscape? I ask this because if you ask me to sing Gorogoa’s tune, I don’t remember anything; I can’t do

that. But if I hear the music, I can recognize that it's Gorogoa because it has a specific tone and character in the sound that reminds me of Gorogoa."

It's more of a creative question than a technical question, like "alright, what's the tone, the tone of this game?" Gorogoa is not sound effects driven, but it's kind of environmental in a way. To me, that's part of the audio strategy, too, where it's like, "all right, we know how music is going to function. What's the tone?" That'd be like a question to figure out in the audio strategy phase, and the tone of Gorogoa is very, very quiet. It's very sparse. I think those things lend themselves to coexisting really well with a soundscape.

You have a ticking clock, and you have outdoor sounds like outdoor city sounds. To me, it was like with the music, you have to be able to hear that stuff under the music or over the music. A lot of that existed before we even wrote any score, so the music couldn't step on it. I think that a lot of that sets the tone. But that to me is all about this whole other bucket that I would call tone. Anything quite like that sort doesn't have a melody is going to sort of start to blend with us. It's gonna feel like a soundscape. It's like a musical soundscape, and then you can get to the point where there's not a lot of difference between the two. And I would say most of the music that I write just from a creative standpoint definitely blends a lot with sound design.

Gorogoa was a game where we just decided we didn't want it to have melody and also functionally, just going back to like what kind of a game it is, melody or anything repetitive or anything – I mean there are some sections in there that are rhythmic – but anything repetitive or melodic or rhythmic would have just would have kind of gotten in the way of solving the puzzles. That goes back to the strategy, which is like, "we don't

want anything that's going to be annoying. We want this relaxing or meditative experience," I should say. "What's going to be the right tone for that?"

10- I asked him about other opportunities for applying adaptive music. "What applications do you see for adaptive music beyond video games?"

Anything that is going to probably be some kind of interactive experience because adaptive music means that it has to adapt to something. I think the other clear place for it is installations where it can adapt. If it doesn't adapt to something that the users or the viewer are doing, you can have music be dependent on things like weather data or seasonal data or time of day, or you know anything that's like a variable that you can use to define some parameters.

"A composer friend of mine (Esfandarmaz, personal communication, July 23, 2021) told me that he wishes to hear adaptive music in real-life games like theme parks."

I think that's interesting. You just have to define what you're adapting it to. Because, obviously, if you have a theme park with thousands and thousands of people, you can't necessarily adapt it to one person. You've got to then change what your variable is. Maybe then it could be based on the time of day, how busy the park is, or bigger information metrics like how many people are in line for this ride.

I think it's an interesting way to sonify data; any kind of situation where you need to represent data with sound, and that can be on products like electric vehicles. It's not music, but it sounds that correlate with information. You can get a lot of information just by listening to different ways to communicate information through sound. It's like ringtones. You can set a different ringtone for a different person, so you can hear it from across the room, and you know who is calling. That's obviously a really simple application for it, but that's a way that we use music and sound to convey information.

11- To discover more adaptive audio middleware, I asked Corelitz, “what tools do you use for making adaptive music?”

> The main tool is your creativity. For games, most of the time, I'm using the same tools that I use for anything; I'm just thinking about it differently. For Gorogoa, it's a whole bunch of different pieces of music that I made in either Logic or Ableton or whatever I was using at the time – I think, was probably logic – and it was really just about "alright, how, how do all these fit together?"
>
> And there are some audio environments that are really great for generative music. I think tools like Max are great for general installation kinds of environments, generative environments. I've used Max a lot; I've used PD a lot. I know that now game engines themselves are getting more and more robust in terms of the way that they can present audio. Unreal Engine has this new real-time synthesis engine that looks really interesting.
>
> I'm curious how people are going to use it because, for me, I always sort of like the control of having of not doing everything totally generatively. To me, there is a component of music that makes it music where it's predictable. It doesn't always have to be totally predictable. But returning to different themes and sounds, as soon as you throw all of that out and make everything generative, then I think you sort of lose your center of gravity a little bit. I'm not saying that stuff doesn't have its place. I'm sure it will find its place, I think it's really exciting, but I think I think we have to be careful about it. Think about what makes a piece of music captivating. Is it possible to keep that and have it be generative? We did it with TumbleSeed.
>
> At one point with TumbleSeed, we had the music changed in an activity and energy level, based on how many enemies were on the screen. And we actually didn't use that.

> We went back to just a looping piece because there was something about every time you land in the forest level and start a new game; we just wanted it to feel the same every time. I'd love to do a truly generative score. I'd love to get a 100% generative score. I just have found myself on many, many projects sort of going into it with that intention and then being like, "you know what we actually want more regularity. We want to come back to something that feels familiar."

12- I elaborated on the challenges facing adaptive music composers in the literature review. Therefore, I asked Corelitz to share his experience. “What limitations does adaptive music have in your opinion?”

> I wouldn’t really call it a limitation. Every time you make a decision in anything, you’re picking one thing and giving up something else. So when you pick an adaptive model, you’re giving up consistency; you’re giving up regularity. A looping piece is going to loop forever, and it’s going to sound exactly the same. You lose that when you go to an adaptive model, which can be good because nobody really wants to sit and hear the same piece for two hours, but you also can potentially lose some of the consistency that comes with that. It’s about which one is more important.
>
> I told my students this because I think there’s a tendency, especially for new composers that are sort of learning everything all at once; there’s a tendency I noticed in myself when I started to want to implement around a creative challenge. But the best solution, most of the time, is just to write a good piece of music. If there’s like a boss battle and you need three minutes of music for it, the best solution is to come up with a piece of music that has some highs and some lows and flows really well and is just thoughtfully composed rather than come up with some complicated system of how all these pieces can work together and evolve and adapt.

> I think in a lot of ways, adaptive music is better when you need to fill a bunch of space. It might not be better for these really dense, intense sections of music. Culturally, most of the way we listen to music is on albums, and we come back to those albums, and we come back to those pieces, and we listen to them over time, and I think there's a certain component of that, that I think if you give up that experience of listening to a piece that has a beginning middle and end, it's harder to sort of connecting with that piece. So you have to be careful. The soundtrack for Gorogoa, for example, is just me playing the game and recording it essentially. Not really (laughter), I mean, I knew the flow of the game, and I knew which pieces to put in what order, how long to loop them for, and I knew I wanted to end up with about an hour, so I did it thoughtfully.

I commented, “besides the game itself, I listened to the Gorogoa soundtrack album. The pieces are arranged in some way to have a specific duration (linear).”

> There’s no soundtrack to Gorogoa. I arranged it on purpose, but that’s the shortcoming of adaptive music: what you gain in flexibility, you give up in consistency, and that’s fine. That has to be the decision that you’re making. Gorogoa was a perfect fit. For Eastward, I wouldn’t go near an adaptive model for that game. That game needs looping music and needs just plain old loops.

13- Lastly, I asked him what solutions he suggests to overcome such challenges. “What solutions do you see for the challenges of making adaptive music? RDR 2 uses loops to produce adaptive music. For example, a new layer of music will be added to the current playing soundtrack with every new event. They could be shorter or longer, but they all are layers of the loop on top of each other. It made me think that this is a limitation that all of these stems should be in harmony and in rhythm with each other because those layers can be played only at certain points. It’s kind of a limitation for the composer and developer.”

To me, that’s a compositional problem; that’s not a technical limitation. In the game that I alluded to a minute ago, we’ve got a similar thing where certain action leads to a new loop. There’s another game I’m working on now that is VR which I wouldn’t necessarily call it adaptive, but it kind of is. We’ve got a similar thing where certain action leads to a new loop. It starts a new layer every time you do something. It adds complexity. The piece is a little harder to develop. The question then is how does it interact with the other things rhythmically, harmonically?

With that, then means that compositionally you can’t have a chord progression. So in this game, my compositional solution to that challenge is that you can’t have a chord progression. Because, as soon as you have a chord progression, things are going to start to sound like they’re clashing. So to me, that was either a limitation or a creative opportunity, and you can look at it the same way; it’s like either side. The upside is you’ve got this really dynamic system that as long as you’re bringing it in on a quarter note, everything’s going to be rhythmically in sync; things are going to interact polyphonically.

I haven't really sat down and defined these things because every project is so different. I think it's really about a relationship between flexibility and structure; the more structure you want, the less flexibility you have. So, if you want a fair amount of flexibility in terms of the way your system works, you've got to give up the structure, and one element of structure and music that you can probably give up is chord progression, as long as you're using pretty diatonic melodies, you're not using a lot of accidentals, then you don't have a lot of potentials to clash if you're using kind of open melodies with. The only thing that really matters is whether it sounds good.

It was kind of the same with Gorogoa. Well, not exactly the same, because Gorogoa doesn't have rhythm. Some of these pieces are going to come in right when you reveal the card, and they're going to loop until they get replaced by something else. The question then is like "well, how do you make something sound good if it can come in anytime," and the answer to that is not a technical challenge; it's compositional.

Then, you have to figure out how to get the game to playback. I am a big proponent of "the less complicated the playback system is, the better." Like most of the heavy lifting should be done on the creative side of things. Gorogoa is just a four-channel playback engine. Most of the heavy lifting was done compositionally where we've got these four pieces, they can play together, they can all start at different times, they can loop forever, they can get interrupted by things.

Conclusion

Corelitz brought up important arguments about adaptive music in video games which come from several years of professional experience. These valuable lessons are practical for researchers in the adaptive audio field and composers who want to learn the craft at the beginning of their careers. The most critical point in this interview is that defining the audio strategy is the number one priority in video game music. It is essential because it means that it is not always necessary to produce adaptive music. Corelitz pointed out the advantages and disadvantages of adaptive music and emphasized that this type of music will find its place, but we should be careful not to fall into the creativity trap. He also gave some tips about composing compatible loops, which I used later in the Creation section. His words also approve my findings in the literature review and the following sections of this research.

Creation

As the final step of my research, I tried to create what I learned in practice and empower other people to understand and expand it. My work includes a series of compatible loops that can be used for creating adaptive music and an explainer video in which I present my findings in simple language. The original files of both works are presented along with this paper to the research committee.

1. Composing Compatible Loops

After studying the soundtrack of Gorogoa and understanding how adaptive music works, I decided to compose compatible loops similar to those created by Corelitz and In B Flat project. I made four tracks for the piano, electric piano, pad, and bass synthesizer in this project.

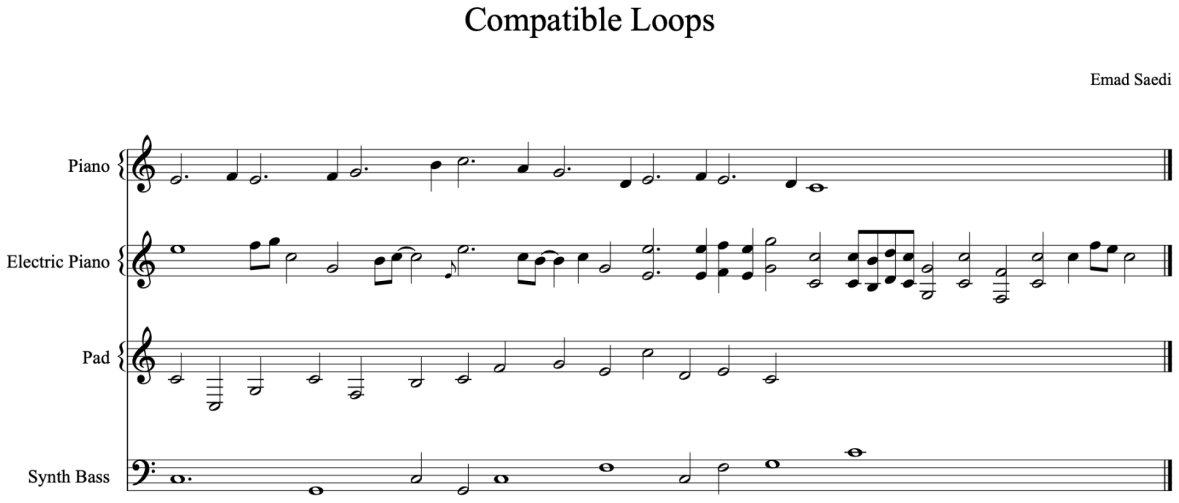
I composed *rhythm-free* (no *time signature*) at the first step, with the tempo set at 62 bpm. Although these loops are rhythm-free, the piano line can be organized in a 4/4 time signature. Therefore, all other lines will be synchronized to the piano line, which creates the illusion of rhythm, while there might not be an actual rhythm or an intention to create rhythm.

All tones are in the same key and scale (C major) to avoid disorder in harmony, resulting in diatonic melodies. Also, I mostly used long notes to create a uniform texture and prevent distraction from hearing too many notes. To avoid chord progression, I composed monophonic lines for each instrument. For the bass, I used basic Tonic (I), Subdominant (IV), and Dominant (V) functions. The piece would still follow the bass harmony, but it will constantly generate new colorful chords and tones that do not need to be locked up in harmony rules. The absence of bass can make the piece even more dynamic harmonically because other tones will not follow the bass anymore. However, bass frequencies make the music sound richer, and I preferred the richer sound over more dynamic chords.

I should note that the final version of compatible loops is different from those presented in the explainer video. The loops in the explainer video have chord progressions in one of the lines, which might cause harmonic distortion. Also, I realized the best results with my loops rhythmically come with a *quarter note quantization*, as Joel Corelitz also mentioned in the interview. Therefore, I made some improvements to the final version presented below:

Figure 6

Sheet music of "30 Minutes" composed by Emad Saedi



These loops are compatible and can be reorganized in unlimited ways using the vertical and horizontal mixing approach. When monophonic loops are layered on top of each other, they allow for polyphonic interaction and dynamic chord progressions as the music progresses. The length of the loops is also different, which makes them even more dynamic. Furthermore, it takes a very long time for the stems to get back to the starting point. Therefore, the whole track can be a long loop from the start until reaching the starting point again. Adding sound design aspects, especially with electronic instruments (e.g., synthesizer modulations), can take the dynamic to a whole new level. An audio demo of my composition called "30 Minutes" is

available on my SoundCloud profile (Saedi, 2021a). The audio file and the stems are also attached to the paper and presented to the research committee in case the online link becomes unavailable.

This approach lets us compose long dynamic tracks quickly, which is practical for producing ambient music and composing for puzzle games. Compatible loops also allow for the concept of *player-as-composer* in video games or other digital environments where the user can mix and match the music through an interactive experience. The mixing and matching of stems have been a music genre called *Mashup*. However, video games provide an opportunity to distribute and consume these stems in a more meaningful and pleasing way. It seems that compatible loops and other modifiable stem types using vertical and horizontal mixing call for a new niche market, presenting new modes of consumption or providing adaptive music as a service. For example, musicians and sound designers can sell adaptive music stems and audio assets for *Unreal Engine* at the *Unreal Engine Marketplace* (Unreal Engine Marketplace, n.d.).

2. Explainer Video

In a short explainer video, I presented the findings of this research:

1. I briefly reviewed the soundtrack of Gorogoa.
2. I introduced vertical and horizontal mixing and compatible loops. To make it more understandable, I visually compared the music stems of Gorogoa to RDR 2.
3. I discussed the relationship between soundscape and music in Gorogoa.

I concluded that music and soundscape two are blending and that with adaptive music techniques, we can gamify music for various uses, including improving the experience of urban living and its soundscape and providing accessibility for disabled people (Saedi, 2021b).

Conclusions and Future Work

Conclusions

I am grateful to conclude my findings in four parts:

1. Adaptive Music in Video Games

Determining the audio strategy is the first and the key step to composing the soundtrack for video games. Not every game requires adaptive music, and sometimes, the best solution is to write a thoughtful piece of linear music. Technology has enabled us to leave technical challenges behind and focus more on compositional challenges. However, adaptive music integration is still a complex process and needs time, thought, and energy. When you compose adaptive music, you design a complex system. Defining the audio strategy, determining and composing cues, arranging the composition and audio files compatible with your strategy are all engineering jobs. Having an engineering mindset helps composers overcome these challenges more easily, creatively, and efficiently. This field asks for well-rounded people, and it might be the best place for multidisciplinary musicians with backgrounds in other areas.

2. The Relationship Between Soundscape and Music

The line between music and soundscape is disappearing, and the use of music as soundscape and soundscape as music is becoming more commonplace every day. Composers are paying more attention to sound design in their works because the sound alone can tell a story.

3. Compatible Loops

By conducting this research, I realized the importance of loops and the vast possibilities they put in front of us. The vertical and horizontal mixing approach suggests new forms in music production, consumption, and distribution.

Compatible loops take that to the next level by allowing us to modify and rearrange stems at any time, create beautiful textures, and keep playing infinitely. Producing adaptive music using compatible loops and a horizontal and vertical mixing approach is ideal for puzzle games. It is also practical for creating ambient music and soundscapes.

4. Gamification

Lastly, there are diverse opportunities with gamification of music. Adaptive audio techniques enable us to gamify music and soundscape easily and take them beyond video games to create better experiences for people. With gamification, we can use adaptive audio to provide services for education and disabled people, convey data, and improve the urban soundscape.

Future work

This research touched on diverse topics which each one can inspire new studies. Adaptive music has been around for more than three decades. However, we are still exploring its potential to find creative audio solutions for interactive environments.

1. The first topic that I suggest is what inspired this study. I started playing video games during the pandemic to relieve my anxiety. I would suggest scholars study the effects of video game music on the player's mental health and wellness.

2. An area of research could be studying the implementation of adaptive audio in real settings. The Gamification of music as a soundscape creates new opportunities to improve our lives which are yet to be discovered.

3. Although procedural music is capable of generating music, it still lacks creative input and expressiveness. Finding solutions to this problem can change everything in the music and entertainment industries.

4. Last but not least, I hope to see more interest in adaptive music and any creative application of music. This requires more flexibility from academic institutions as well as the industry. As Hutchings and McCormack found, translation from research to commercial adoption has been slow. To connect academia and industry, we need to offer more creative programs and courses in universities, such as video game music, soundscape composition, and welcome people from diverse backgrounds. Universities also need to show flexibility with industry experts and invite them for scholarly research. Academic restrictions only limit the power of creativity. I also wish to see the interest in connecting with universities from the industry too. This is a two-way path.

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