The Dialogue Between Image and Sound

An Exploration of Music-Inspired Digital Art Creation Using Algorithmic Generators

Mehdi Farahani

A thesis presented to OCAD University

in partial fulfillment of the requirements for the degree of

Master of Design in Digital Futures

Canada, 2023

Author's Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners. I authorize OCAD University to lend this thesis to other institutions or individuals for the purpose of scholarly research. I understand that my thesis may be made electronically available to the public. I further authorize OCAD University to reproduce this thesis by photocopying or by other means, in total or in part, at the request of other institutions or individuals for the purpose of scholarly research.

Mehdi Farahani

Advisories

Prof. Adam Tindale

Prof. Bentley Jarvis

Abstract

This study aims to provide both a theoretical and practical approach to developing Persian music visualizations capable of eliciting emotional responses from audiences. In today's era of increasing digitalization, music visualization has emerged as a prominent phenomenon. Numerous theoretical inquiries have confirmed that the integration of artistic visual elements with musical performances can evoke strong emotional reactions compared to auditory experiences alone. However, it is crucial to recognize that the exploration of harmonious and purposeful integration between visual and auditory elements within the realms of artistic practices and cultural aesthetics is still in its nascent stages. This scholarly investigation seeks to address these gaps and explore methodologies that facilitate the establishment of a coherent and meaningful dialogue between Persian visual imagery and Persian musical compositions.

Keywords: Persian music visualization, Interactive music visualization, Generative art, Machine learning, Computational design, Real-time

Acknowledgments

In exploring this thesis, I have stood on the shoulders of many who have supported, guided, and inspired me throughout this journey. Foremost among them is my primary advisor, Dr. Adam Tindale. His friendly demeanor was what initially drew me to OCAD University, and I'm profoundly grateful for that. His patience and expertise have not only aided in navigating this thesis but have also provided a glimpse of the kind of professor I have always admired. His invaluable lessons and transformative guidance have left an enduring imprint on my journey over the past two years, and his influence on my various projects has been truly transformative. I'd like to extend my heartfelt thanks to my secondary advisor, Prof. Bentley Jarvis. His meticulous review of my thesis and the invaluable feedback he provided have been pivotal in elevating the quality of my work, and I'm grateful for his unwavering dedication to my success. I'm also indebted to the Digital Futures department for generously providing the essential resources and infrastructure that underpinned my research. Additionally, I express my profound appreciation to Prof. Cindy Poremba, Prof. Kate Hartman, Prof. Simone Jones, and Prof. Emma Westecott for their enlightening discussions and the wealth of expertise they shared, enriching my academic journey. I am grateful to all my lovely and talented classmates, their boundless creativity and unwavering dedication have been a constant source of inspiration, driving me to reach higher. Last but not least, I extend deep appreciation to my beloved spouse, Zahra Syavash, who stood by me throughout the highs and lows of this journey, offering patience, support, and unwavering encouragement. Ultimately, this thesis represents the collective efforts, wisdom, and encouragement of the incredible individuals mentioned above. Your contributions have been indispensable, and I'm profoundly grateful for the part you've played in this academic endeavor. I couldn't have accomplished it without your support.

" As no 'dissonant notes' exist in music, nor in painting 'inharmony,' in these two art expressions every sound, whether harmony or discord, is beautiful (appropriate) if it results from inner need."

Wassily Kandinsky, On The Spiritual In Art

Table of Contents

Part 2: From Perception to Artistic Expression

Part 3: Persian Art

Part 4: Iterative Prototype

Conclusion

List of Figures

Figure 14. Farahani, M. (2021). Illustration for Book Cover: Metal Pen and Ink on Paper. Emulating the Resonance of the Kemancheh. Mahoor Publication.

Figure 15. Esfahani, M. Gh. (19th century). The Diagonal Compositions of Siyāh Mashq. Reference: National Library of Iran.

Figure 16. Unknown Artist. (19th century). Siyāh Mashq Calligraphy Based on Nasta'liq Script. Reference: Library of Congress African and Middle Eastern Division, Washington, D.C. 20540, USA.

Figure 17. Mafi, R. (1974). Calligraphic Painting, Oil on Canvas. Reference: Private Collection.

Figure 18. Zenderoudi, C. H. (1970s). Calligraphic Painting, Oil on Canvas. Reference: Private Collection.

Figure 19. Farahani, M. (2015). Illustration and Cover Design for Vancouver Symphony Orchestra.

Figure 20. Ehsaei, M. (2013). Calligraphic Painting, Oil on Canvas. Reference: Private Collection.

Figure 21. Farahani, M. (2022). Calligraphy of Letters in the Nastaliq Style, Using a Traditional Reed Pen.

Figure 22. Training an Audio Model by Setar and Vocal (200 Audio Sample).

Figure 23. Training an Audio Model by Musical Note (Setar & Vocal).

Figure 24. Farahani, M. (2022). A Computational Sketch Based on Diagonal Compositions of Siyāh Mashq.

Figure 25. Farahani, M. (2022). A Computational Sketch Based on "Siyāh Mashq" Style.

Figure 26. Farahani, M. (2022). A Computational Sketch Based on Contemporary Composition of "Calligraphic Painting" Style.

Figure 27. Farahani, M. (2022). A Computational Sketch Based on "Calligraphic Painting" Style.

Figure 28. Farahani, M. (2022). A Computational Sketch Based on the Fusion of Calligraphy Compositions.

Figure 29. Farahani, M. (2022). A Computational Sketch Based on the Fusion of Calligraphy Compositions.

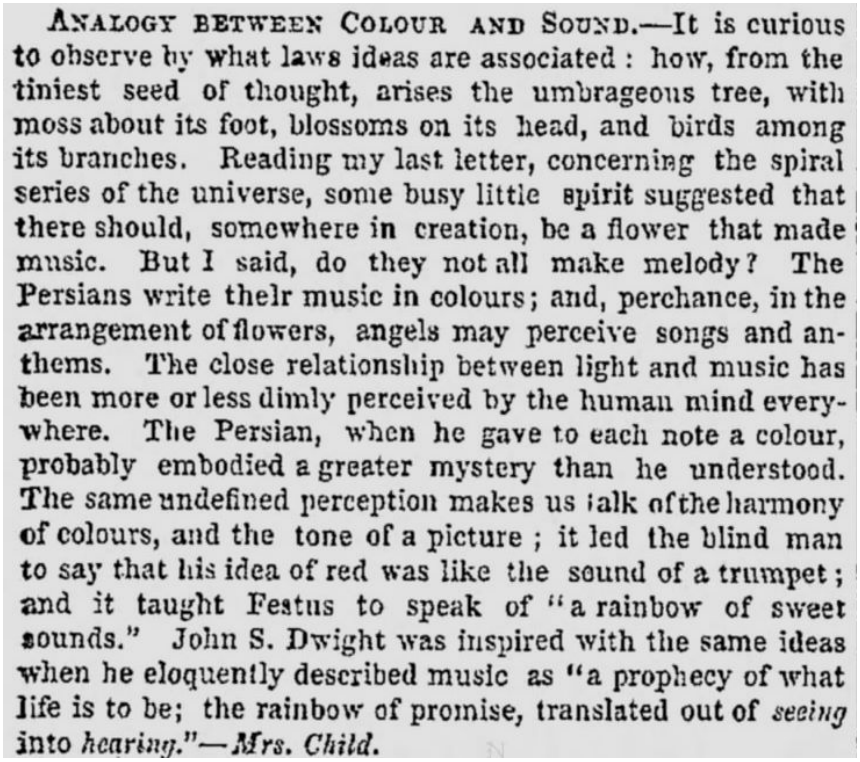
Figure 30. Farahani, M. (2022). A Computational Sketch Based on the Fusion of Calligraphy Compositions.

Figure 31. Farahani, M. (2022). A Computational Sketch Based on the Fusion of Calligraphy Compositions.

Introduction

The hidden and inherent meanings of images and sounds have always fascinated me as a musician and visual artist. I was constantly trying to find a way to have a rational conversation between music and the visual arts. Each time I designed and illustrated a music book or album cover, a music poster, or a music children's book, I tried to find a traditional way to visualize sounds. However, thanks to the development of technology, we can now see sounds and perceive images in more tangible ways.

When I was researching and writing my first book, I had to spend hours digging through old newspapers and primary sources, hoping to find something of value. One day, I came across an article about Persian music that discussed the intriguing concept of the analogy between color and sound in Persian music. (Figure. 1)



ANALOGY BETWEEN COLOUR AND SOUND.—It is curious to observe by what laws ideas are associated: how, from the tiniest seed of thought, arises the umbrageous tree, with moss about its foot, blossoms on its head, and birds among its branches. Reading my last letter, concerning the spiral series of the universe, some busy little spirit suggested that there should, somewhere in creation, be a flower that made music. But I said, do they not all make melody? The Persians write their music in colours; and, perchance, in the arrangement of flowers, angels may perceive songs and anthems. The close relationship between light and music has been more or less dimly perceived by the human mind everywhere. The Persian, when he gave to each note a colour, probably embodied a greater mystery than he understood. The same undefined perception makes us talk of the harmony of colours, and the tone of a picture; it led the blind man to say that his idea of red was like the sound of a trumpet; and it taught Festus to speak of "a rainbow of sweet sounds." John S. Dwight was inspired with the same ideas when he eloquently described music as "a prophecy of what life is to be; the rainbow of promise, translated out of *seeing* into *hearing*."—*Mrs. Child.*

Figure 1. Sunday, December 24, 1843, LONDON, Lloyd's Weekly Newspaper

At the time of writing this article (1843), the first human attempts to record sound and visualize music (technically) had not yet begun. But the lyrical words of this article drew my attention:

> *"Persians write their music in colors"*
> *"A rainbow of sweet sounds"*
> *Or " Music as a rainbow of promise"*

I'm struck by the idea that two hundred years ago, there was an inclination to perceive music visually. These phrases, at first glance, possess a lyrical or poetic essence. However, they exhibit the application of figurative language and metaphors to articulate the intricate relationship between music and colors, thereby eliciting vivid imagery and evoking emotions. These poetic expressions serve the purpose of conveying specific themes or ideas concerning music visualization. The phrase *"Persians write their music in colors"* exemplifies this association within Persia's cultural context. It suggests that the act of composing or performing music in Persia entails a harmonious fusion of musical notes interwoven with vibrant hues, possibly mirroring the opulent and colorful traditions of Persian music and Persian visual art.
This idea intrigued me and I realized that the power of perception can create something so meaningful that it exists beyond the comprehension of its creator. With this perspective, the artist's objectives are not only to create but also to enhance perception. Artistic expression can provoke the viewer to consider a different point of view, allowing them to see the world in a new way. Exploring the mystical and influential relationship between image and sound became an integral part of my research, as I sought to understand how the arts had been interrelated for centuries in Persian culture.
One of the recent studies conducted by Tiihonen et al. (2017) examined the conceptual understanding of pleasure induced by music and visual art in empirical research over the past 20 years. The findings of this study demonstrate the variations in how pleasure is approached in music studies compared to visual art studies. Based on the findings, the authors suggest that integrating “music” and “visual art” into a multi-modal framework can provide a more

comprehensive understanding of pleasure in response to aesthetic artifacts. (Tiihonen et al., 2017)

For my project, I am attempting to create a model that integrates Persian music with the visual elements of Persian calligraphy. The present study acknowledges that it does not have the scope for in-depth investigations into cultural aesthetics or delving into the philosophy of art and advanced computational techniques. While a passing reference is made to these aspects, the study primarily focuses on experimenting with the techniques within the field of new media art, particularly the unified approach to Persian music visualization. Further research is needed to thoroughly investigate and understand the intricate relationship between cultural aesthetics, music visualization, and the broader philosophical underpinnings of art within the context of new media.

While recent years have witnessed an upsurge in the utilization of emerging technology in Western art, including experiments by emerging artists combining images and sound through various techniques from computer-generated imagery to augmented reality, there remains a scarcity of artworks that integrate Persian visual aesthetics to Persian music. In fact, the attempt to visualize music based on Persian visual aesthetics has not yet commenced.

The present study aims to explore how the distinctive visual elements of Persian art can be used in combination with traditional musical styles to create new forms of artistic expression. Therefore, the purpose of this project is to test the musical and visual map in Persian art.

This study comprises four distinct chapters, each addressing specific aspects of music visualization and its creative methodologies. In the initial chapter, I present a historical survey of music visualization, elucidating the creative techniques employed in both historical and contemporary contexts. Moreover, this chapter delves into the realm of experimental exercises and fundamental theoretical discussions concerning the fusion of visual imagery and auditory elements. Given the dearth of a comprehensive framework for categorizing the diverse genres of music visualization, I have endeavored to construct a structured framework that classifies these genres based on the definitions provided in existing literature.

The second chapter of this study concentrates on exploring the dynamic interaction between visual imagery and auditory elements in the realm of music visualization. It also delves into the

theoretical approaches underpinning music visualization and underscores the inherent importance of unity in the context of artistic expression.

Moving on to the third chapter, I delve into the realm of Persian art ontology, providing a point of view of the intricate relationship between Persian Music and Persian Calligraphy. Within this discourse, I elucidate my rationale for selecting Persian Nastaliq letters as the foundational visual aesthetic to establish a connection with Persian music, as opposed to alternative visual elements.

In the fourth and final chapter, I embark on an exploration of computational methodologies for generating visuals rooted in Persian visual culture. This chapter delves into techniques such as machine learning, computation, and generative imagery. Furthermore, I discuss the prototype models I have developed to address the central inquiries posed throughout this study.

Research questions

The primary question in this study is: How can computational methodologies facilitate the harmonization of aesthetic features in Persian visual arts with those of Persian traditional music? Bringing together computational methodologies to harmonize aesthetic features in Persian visual arts with those in Persian traditional music involves a blend of technology, art, and cultural insight. To address this question, it is imperative to first delve into the realm of music visualization. Understanding the notions and concepts associated with visualizing music within the domains of art and technology is pivotal for this study. Consequently, we should seek answers to questions such as:

What is music visualization? How to manage visual aesthetic characteristics in music visualization? Is the dialogue between images and sounds a subjective matter? Or a personal experience and perception? Are the aesthetic qualities of musical waves transferable on the screen?

In the first and second chapters, I will endeavor to explore these concepts and provide answers to the associated questions. Understanding the interplay between the languages of music and visual arts becomes crucial, particularly in their convergence to produce auditory and visual experiences. Exploring the distinctive visual culture of Persian art unveils profound insights into

its intricate beauty. To create art aligned with Persian aesthetic standards, it's essential to tackle the question: What are the defining aesthetic features of Persian visual arts and traditional music, and how do they both diverge and intersect?

The third chapter delves into the ontology of Persian art, focusing on Persian calligraphy and music, revealing their philosophical, spiritual, and cultural underpinnings to offer readers a glimpse into their foundations.

I hypothesize that if computational methods were tailored to recognize and represent the aesthetic intricacies of Iranian visual arts and traditional music, the utilization of a generative system based on randomness could potentially facilitate the exploration of a wide array of visual possibilities. Hence, in the concluding chapter, I will delve into computational techniques aimed at bridging the features of Persian music and visual aesthetics.

Methodology

The primary objective of this study is to investigate how computational methodologies can facilitate the harmonization of aesthetic features in Persian visual arts with those of Persian traditional music. Considering the cross-disciplinary essence of this research, a multi-modal approach is employed. To enhance the understanding of the visualization model's efficacy, this research utilizes a mixed methods strategy. Recognizing the constraints of earlier theoretical explorations on Persian music visualization, this study melds a critical analytical perspective with computational techniques, drawing from Persian visual motifs, to craft a reasonable music visualization framework. This study will begin with a comprehensive literature review. Academic articles, books, and reports concerning traditional music visualization techniques and computational methodologies in art will be reviewed. This will provide a foundational understanding and contextualize the research.

I conduct a comparative analysis of the distinct aesthetic features characterizing Persian visual arts and Persian traditional music. This analysis considers commonalities and differences, recognizing the influence of cultural and historical context.

I am employing computational languages with the specific objective of harmonizing the aesthetic elements inherent in Persian visual arts and music. This methodology comprises several sequential steps: Firstly, an exploration of existing computational methodologies and tools tailored for visualizing music and generating art. Secondly, I am implementing Persian visual elements through dedicated computational techniques. To conduct this research, I will meticulously craft a series of traditional Iranian calligraphy and musical pieces for a comprehensive aesthetic analysis. This analysis will involve a close examination of elements such as color, form, rhythm, and composition, aiming to derive a set of distinct aesthetic parameters characteristic of Persian visual and auditory arts. Following this, I will develop programming languages to integrate these identified aesthetic features from Persian arts into a computational model. This model will be the cornerstone for converting traditional music data into visual representations that authentically portray Persian aesthetics.

Part 1: Literature review

Introduction to Part 1

The realm of music visualization is a rich tapestry of history, methodologies, and evolving techniques. Rooted in the ancient world's passion for intertwining auditory and visual stimuli, it has metamorphosed through the centuries to incorporate advanced technologies and innovative approaches. As we navigate through this extensive terrain, we delve into the vague definitions surrounding music visualization, distinguishing it from its close relative, sound visualization. Both concepts, though intertwined, cater to diverse objectives and interpretations. By examining these practices within their historical framework, we gain insights into their evolution and the profound impact of technological advancements on their development. Classical methods of visualizing music have given way to contemporary techniques that leverage the power of new media, artificial intelligence, and generative approaches. Furthermore, an evaluation of recent artistic practices provides a comprehensive understanding of the current landscape and emerging trends in the field. This section endeavors to shed light on the myriad ways in which visual representations enhance, complement, and transform our musical experiences.

1.1 Music Visualization

Music visualization is the process of transforming sound waves into visual images, often in real-time. This can be accomplished in a variety of ways, including through the use of visual elements such as colors, shapes, and forms in different compositions and environments. It is also used to enhance the listening experience and make the music more visually appealing (Isaacson, 2023). Visualization plugins like Geiss (1999), MilkDrop (2001), and G-Force (2001) are traditional examples of how visual communication is employed to synchronize images with music. In order to gain a comprehensive understanding of music visualization approaches, it is essential to explore the definitions and historical connections between music and imagery. By delving into these aspects, we can develop a deeper insight into the various methods employed to visually represent music.

1.1.1 Definitions

Based on my investigation, there is a lack of specific information regarding music visualization in prominent music dictionaries, referenced encyclopedias, and etymology dictionaries up to the current date. Through an examination of various dictionaries in the fields of music and visual arts, it can be inferred that a comprehensive definition of music visualization is yet to be established. Each definition offers insights into specific facets of the concept; however, none of them encapsulate the entirety of music visualization. Notably, the Oxford[1], Cambridge[2], and Harvard dictionaries of music do not provide a definition for the term "visualization of music" or "music visualization." Additionally, Merriam-Webster presents a vague definition that does not align with the contemporary understanding of musical visualization. According to Merriam-Webster, it refers to *"the creation of a modern or ballet dance entirely from designs suggested by musical accompaniment" !* [3]

Although the term "music visualization" may not be explicitly featured in these dictionaries, its definition within the realm of computing seems to be well-defined. Music visualization pertains to the generation of visual representations, both analog and digital, based on music, which enhances the auditory experience and provides a more immersive engagement with the music. This concept traces its roots back to ancient civilizations and early forms of artistic performances, such as drama, dance, and theater.

1.1.2 Sound Visualization and Music Visualization

Artists and technologists often use the terms "Sound Visualization" and "Music Visualization" interchangeably and do not make a clear distinction between the two concepts. Based on my research, I did not come across any scholarly or academic studies that specifically address the differentiation between "Sound Visualization" and "Music Visualization." This might be due to

---

[1]. https://www.oxfordmusiconline.com/search?q=music+visualization&searchBtn=Search&isQuickSearch=true. Accessed 28 Dec. 2022.

[2]. See *"A Dictionary of Musical Terms"* published by Cambridge University Press for a comprehensive list of musical terms and their definitions.

[3]. "Music visualization." Merriam-Webster.com Dictionary, Merriam-Webster, https://www.merriam-webster.com/dictionary/music%20visualization. Accessed 28 Dec. 2022.

the close relationship between “sound”" and “music,” and visualizing them often involves similar techniques and approaches. However, it is important to recognize that there is a difference between the two.

Despite this distinction, in recent years, most of the works people have presented for their music visualization through various creative and artistic mediums in the realm of new media and experimental art, such as Audio-Visual Installation, Generative Art, Interactive Installation, Projection Mapping, Audio-Responsive Art, Sound Reactive, or (VR) and (AR) Music Visualization, have not been aesthetically appealing, based on the aesthetic considerations in visual arts.

Before delving into the concepts of "Sound Visualization" and "Music Visualization," it is essential to establish a clear understanding of the terms "sound" and "music."

Scientifically, the differentiation between "sound" and "music" is well-established. The term "sound" encompasses any audible vibration that propagates through a medium, such as air or water, and can be perceived by the human ear. This broad definition includes all types of audible vibrations, irrespective of whether they are of a musical or non-musical nature. On the other hand, "music" encapsulates a particular manifestation of structured sound, arising from the purposeful amalgamation of components like melody, rhythm, harmony, and timbre. Musicians, through deliberate composition and arrangement, craft unified and expressive compositions. However, it's worth noting that while this definition aligns with traditional notions, it may not fully encompass experimental music and new media art. These new forms frequently challenge established musical norms, pushing beyond conventional boundaries in composition, performance, and sound production.

The distinction between “sound” and “music” lies in their organization and intention. Sounds can exist in either an organized or unorganized manner and may be intentional or unintentional. Examples of unorganized and unintentional sounds encompass natural sounds, environmental noises, and random auditory occurrences. Conversely, music is inherently organized and structured with the purpose of eliciting emotions, narrating stories, expressing ideas, and conveying artistic intentions. Composers and musicians make deliberate choices to imbue music with a specific intent.

Another aspect of differentiation lies in the aesthetic experience evoked by “sound” and “music”. While sounds can evoke various responses from individuals, they may not necessarily lead to the profound aesthetic experiences often associated with music. Music, designed to offer aesthetic pleasure, possesses the power to inspire, soothe, excite, or provoke a wide range of emotions within its listeners.

The components of sound and music also contribute to their disparities. Sound can be a single tone, noise, or a combination of different frequencies and amplitudes, and it may lack the structured patterns of rhythm or melody found in music. Conversely, music consists of various essential musical elements, such as melody, which comprises a sequence of pitches; rhythm, encompassing patterns of sound durations; harmony, representing simultaneous pitches; and timbre, defining the unique tone color of instruments or voices.

Furthermore, interpretations of sound and music can differ based on the context and the individual listener's perspective. Sounds, particularly those encountered in everyday life, may be subject to varying interpretations depending on the environmental conditions and personal experiences of the listener. In contrast, music is usually created with a more defined intention, and its interpretation is often guided by the artistic expression and thought of the composer or performer.

By understanding these fundamental distinctions between “sound” and “music”, we can approach the concepts of "Sound Visualization" and "Music Visualization" with a more comprehensive perspective. With the elucidation of these definitions, a clear distinction emerges between "Sound Visualization" and "Music Visualization":

“Sound visualization” encompasses the visualization of a broad range of sounds, encompassing natural sounds, spoken words, environmental noises, and music. Its primary objective is to visually represent the fundamental characteristics of sound waves, including aspects such as frequency, amplitude, and duration. The visualizations in sound visualization focus on providing insights into the acoustic properties of sound, often emphasizing clarity and accuracy. This field employs various visual elements such as color, shape, or movement to convey information about frequencies, amplitudes, and temporal patterns, facilitating scientific analysis and exploration.

On the other hand, “music visualization” is a specialized discipline that concentrates specifically on visualizing music, which comprises organized sound with discernible pitch, rhythm, and melody. The fundamental purpose of music visualization is to create visual representations that are closely synchronized with the musical elements, accentuating the emotional and artistic dimensions of the music. Unlike sound visualization, aesthetics in music visualization are more attuned to artistic expression and emotional impact. These visualizations are designed to evoke particular moods, feelings, meanings, or visual metaphors that resonate with the themes and essence of the music. By doing so, the aesthetics in music visualization aim to enrich the overall listening experience, providing a captivating visual accompaniment that enhances the musical journey for the audience.

In the realm of sound visualization, the incorporation of synesthetic elements is possible, wherein visual patterns or colors are generated based on the acoustic properties of sound. However, these visualizations do not necessarily strive to synchronize with the structure or content of the music being represented. Conversely, music visualization incorporates synesthesia in a more deliberate and structured manner. The visual elements are intentionally designed to respond and synchronize with specific musical elements, such as beats, melodies, and harmonies. This amalgamation of visual and auditory senses creates a multisensory experience, where the visuals and music complement and enrich each other, intensifying the impact on the audience.

Practically, sound visualization finds its applications across various scientific and technical domains, including acoustic research, data analysis, and audio engineering. In these areas, it is employed to study the properties of sound waves, identify patterns, and analyze complex audio signals. In contrast, music visualization primarily thrives within artistic and entertainment contexts, where it serves as a powerful tool in mediums such as music videos, live performances, and interactive audio-visual installations. The captivating visualizations in music visualization effectively heighten audience engagement, offering an immersive and visually stimulating experience that harmoniously aligns with the auditory elements of the music.

In summary, while “sound visualization” pertains to the representation of a diverse array of sound types, “music visualization” specifically tailors its visualizations to accentuate the artistic and emotional aspects of music. Aesthetically, “sound visualization” prioritizes accuracy and

clarity, whereas “music visualization” gravitates towards artistic expression and emotional impact. The incorporation of synesthetic elements further distinguishes the two disciplines, with music visualization deliberately synchronizing visuals with specific musical elements, creating a rich and multisensory experience for the audience.

1.1.3 Visualization of Sounds in Historical Context

Sound visualization, also known as “sound wave visualization” or “audio visualization”, refers to the process of representing sound or audio data in a visual format. The goal of sound visualization is to create a graphical or animated representation that allows individuals to see and interpret the characteristics of sound waves in a more intuitive and engaging manner.
Exploring visualizing sound and music within a historical context proves to be an invaluable resource for comprehending shifts in culture and aesthetics throughout the ages. Today, the use of visualizations to express a deeper understanding of musical compositions is widespread, and researchers are developing new approaches and methods; however, there is a long history of using visual elements in association with music.
Since the term "music visualization" is modern and was not used or recognized in ancient times, applying it to describe ancient arts would be an anachronism both historically and methodologically. However, it's worth noting that while the terminology might be modern, the concept of visualizing music or linking visual arts with auditory experiences might have existed in some form in ancient times. Using a modern term to describe an ancient practice can be helpful for contemporary understanding, but it's essential to acknowledge the historical context and I try to avoid presenting this term as if it was used during that period.
The concept of combining visual images with sounds and music is something that has excited people for thousands of years. Music [4] and dance [5] were incredibly important to the ancient world; not only did they capture the emotions of life, but they were also a form of storytelling, allowing us to view art as a source of history (Hemingway, 2000) . Ancient art, from the

[4] For 'Music & Dance in Ancient Greece' See: https://www.metmuseum.org/art/collection/search/253349 Accessed 8 Jan. 2023.
[5] For 'Music & Dance in Ancient Egypt' See: https://www.worldhistory.org/article/1075/music--dance-in-ancient-egypt/ Accessed 8 Jan. 2023.

prehistoric wall paintings of Magura Cave, Bulgaria [6], to ceramic and bowl paintings in Persia [7], often depicts images of music and dance to capture the appeal of this combination.

Due to the relative youth of the field, comprehensive historical research on visualizing music remains largely unexplored until now. The earliest attempt to visualize music or sound can be traced back to the ancient Greek mathematician Pythagoras, who, around the 4th century BCE, observed that when a metal plate was vibrated by a bow or by striking it, the grains of sand or powder sprinkled on the plate would arrange themselves into distinct patterns. Although this visualization was not in the form of graphical representations as we know them today, it marked an essential early step in understanding the relationship between sound and visual patterns. (Morris and Sharman 2002: 11)

During the early 19th century, Ernst Chladni, a German scientist, made noteworthy progress in the emerging fields of sound and image science. In 1802, Chladni published "Die Akustik," [8] a descriptive treatise that laid the foundation for the visualization of sound. Building upon 17th-century observations made by Robert Hooke, Chladni developed a straightforward method to make sound visible. (Chladni, 1802)

Chladni's primary focus was on the vibration of thin plates, which he considered to be extended two-dimensional objects. Instead of just single points, Chladni found that the nodes on these plates formed a network of lines. Figure 2 & 3 show the Patterns produced by certain sounds. To make sound visible, he invented a musical instrument comprising glass disks of various shapes and sizes that were stroked at their edges with a violin bow. By sprinkling the plate with sand, Chladni made the pattern of vibration visible. The sand reacted to the vibration at the antinodes, moving about and collecting at the stationary nodes, ultimately revealing the overall mode pattern. This delightful musical experiment resulted in remarkable and strikingly symmetric patterns.[9] (e.g., Figure 2)

---

[6] . https://encyclopedia.pub/entry/440
[7] . https://asia-archive.si.edu/ladies-of-the-east-representation-of-women-on-sasanian-ewers/
[8] . https://archive.org/details/b22017604/mode/2up
[9] . https://sciencedemonstrations.fas.harvard.edu/presentations/chladni-plates

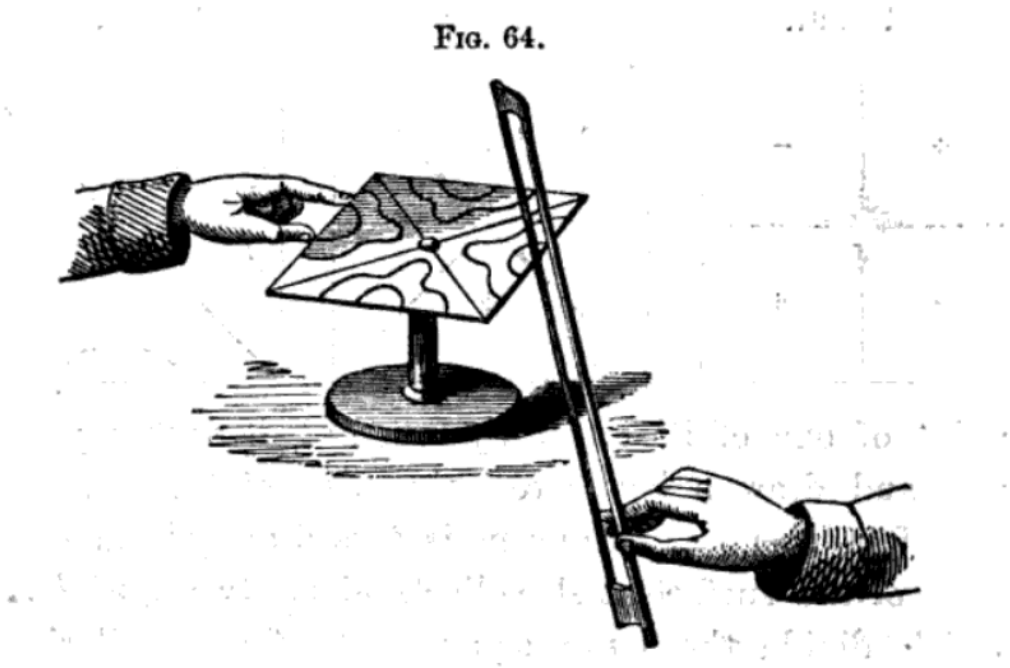


Figure 2: An illustration of the Chladni plate technique
(Using a violin bow to create vibrations on the plate), Source: (Tyndall 1867, 142) [10]

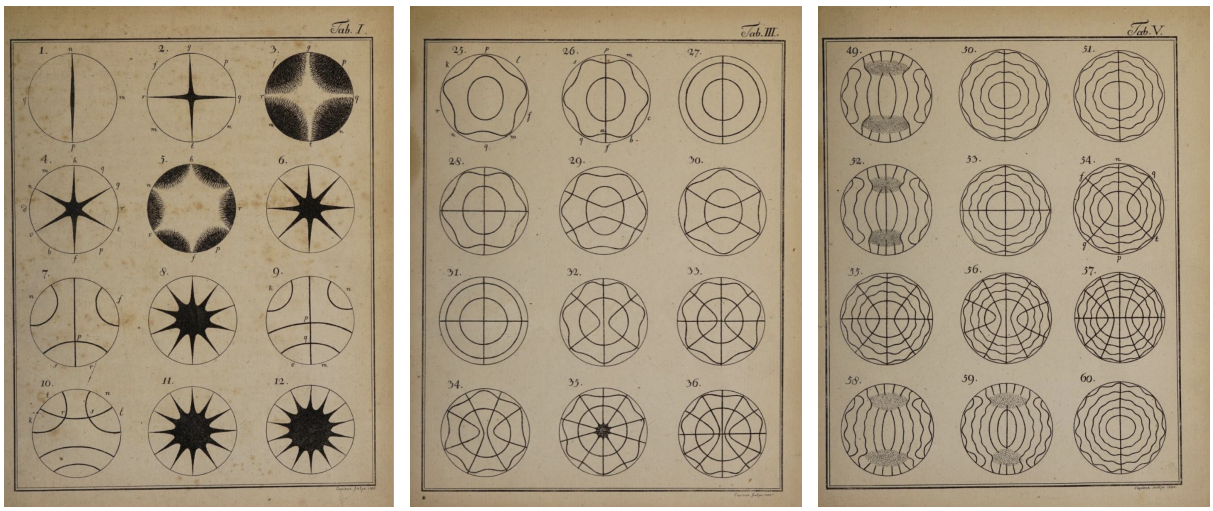


Figure 3: Patterns produced by certain sounds, Source: (Chladni, 1787: 79) [11]

[10] https://books.google.ca/books?id=2bMPAAAAYAAJ&printsec=frontcover&source=gbs_ge_summary_r&cad=0#v=onepage&q&f=false

[11] https://archive.org/details/entdeckungenuber00chla/page/78/mode/2up

Chladni's discoveries and patterns garnered attention from leading French scientists, and in 1808, he demonstrated his experiment to Napoleon during a two-hour audience. Napoleon, who had an interest in mathematics, was impressed, leading him to fund a French edition of "Die Akustik" and institute a prize for the mathematical explanation of Chladni's patterns, with the value of the prize set at one kilogram of gold. (Stöckmann, 19: 2007)

The prize eventually found its recipient in 1816, when Sophie Germain, a pioneering female mathematician, won it on her third attempt. Germain's work on Chladni patterns earned her recognition as one of the greatest mathematicians of the modern era. Despite her significant contributions to number theory and Fermat's Last Theorem, she faced challenges in gaining acceptance as a mathematician in a male-dominated field, often resorting to using a pseudonym to hide her gender.

However, Sophie Germain's solution did not fully resolve the controversy surrounding the mathematical theory of patterns. It took further developments in more powerful "variational" methods, based on the energy stored in the plate by small amounts of bending, to provide a complete understanding of the phenomena. German physicist Gustav Robert Kirchoff's work in 1850, deriving the correct expression for bending energy, contributed to the theory's ultimate completion. (Stöckmann, 21: 2007)

Despite challenges and controversies, the contributions of Ernst Chladni and Sophie Germain played crucial roles in advancing the visualization and understanding of sound, paving the way for future developments in the field of acoustics and beyond. Their work continues to inspire scientists and mathematicians in the exploration of the relationship between sound, vibration, and visual patterns.

1.1.3.1 Phonautograph

The first significant and innovative technique in the field of “music visualization” according to the stated definition can be dated back to a century ago. French typographer Édouard-Léon Scott de Martinville (1817-1879) invented a machine in 1857 to make a visual record of sound waves traveling through the air. He gave it the name "Phonautograph." (e.g., Figure 4) Scott wanted to

use sound to create a form of writing, a phenomenon that today's artificial algorithms recognize. He delivered sound as wavy stripes traced through a coating of soot on a cylinder or piece of paper. his machine produced the lines with the aid of a vibrating stylus that was propelled into motion by a flexible, thin sheet that responded to sound waves. (Morton, 2 : 2004)

Based on my research, considering the provided definitions and the live sound-driven process through which the mechanical machine generates visual elements in real-time, I attribute the inception of "music visualization" techniques to the time of Scatt's machine invention. It's important to emphasize that there are no scholarly records within the field of music visualization studies to reference this particular technique and machine.

Using this idea, Edison was able to invent the phonograph machine. From the beginning of time, the sound was invisible. Scott's machine made it visible. (e.g., Figure 5) However, not only has Scott's machine been forgotten in historical texts [12], but the analog sound visualization research program has also taken a different path.

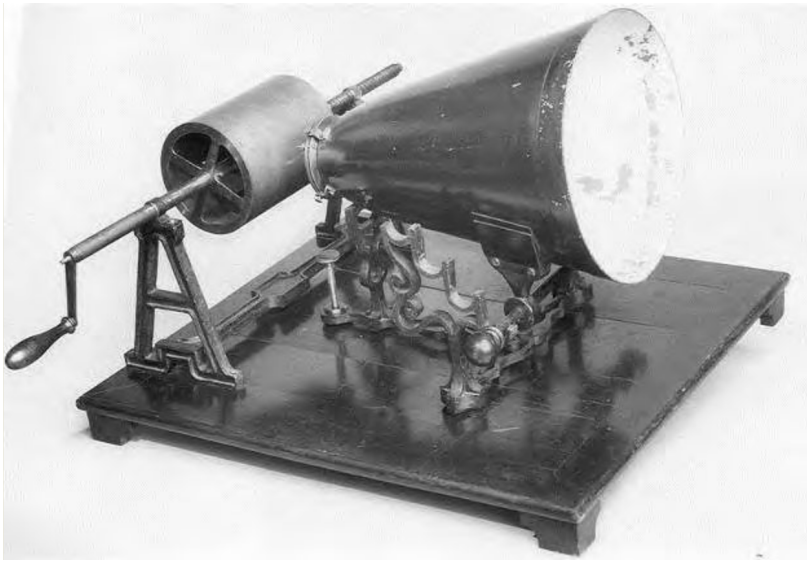


Figure 4: Phonautograph, Source: Smithsonian Institution Libraries

[12] . There are also no particular entries on the Phonautograph in Encyclopedia. (See Marko. G. 1993. Encyclopedia).

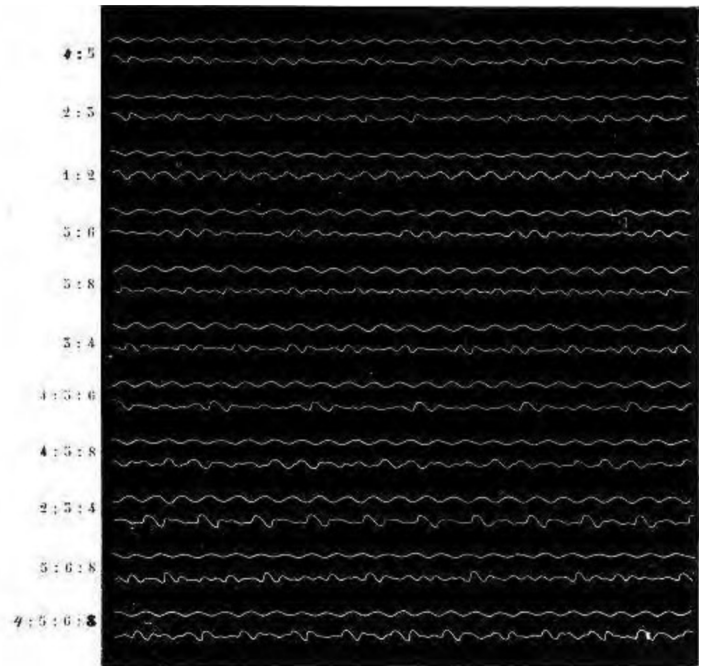


Figure 5: Analogue sound waves are depicted here on a phonautograph recording from an 1865 catalog of Karl Rudolph Koenig's acoustical instruments.
Source: Smithsonian Institution Libraries

1.1.4 Music Visualization's Evolution

When we think about human history, we find numerous instances where visual arts and music coalesce, giving birth to enthralling synesthetic experiences. From the intricate motifs of ancient tribal dances that resonated with primal drum beats to the grandeur of Renaissance art that depicted celestial harmonies, the interplay between sight and sound has always been an intrinsic part of human culture.

The convergence of music and visual art has witnessed several pivotal moments in history. For instance, during the Romantic era, artists and composers like Kandinsky and Wagner harbored a shared vision of uniting different art forms into a holistic Gesamtkunstwerk[13] (total artwork).

[13] "Gesamtkunstwerk" is a German term for artworks where multiple arts like music, visuals, and theater merge into one unified experience.

This symbiotic relationship between the visual and auditory senses paved the way for subsequent explorations in the realm of multimedia.

Music visualization has undergone significant evolution in the modern era, driven by advancements in technology and artistic experimentation. In the early days, visual representations of music were limited to simple graphical representations and mechanical machines, such as Phonatograph and oscilloscope displays. However, with the advent of computer graphics and multimedia technologies, the possibilities for music visualization expanded exponentially.

As technology advanced and screens became more widespread, music visualization was developed to create dynamic art that could be seen on television. In the 1960s television opened up new avenues of expression and helped to popularize this new form of art. By utilizing the television medium, artists founded the new discipline of video art. With the global shift towards digitalization from early attempts at the relationship between visual art and music to procedural animation[14]Computational music visualization became widespread, and many historical studies showed that, compared to audio-only performances, audiovisual congruent performances can lead to a more intense emotional response.

John Whitney (1917-1995); one of the pioneers of computer graphics and abstract film, is recognized as one of the first creators to have achieved the goal of producing works of art based on the sounds of music. He believed: "A musical note is a graphic image too" (Sito 2013: 23) His creation of a homemade mechanical device that allowed him to choreograph abstract forms in a visual medium is one of his greatest accomplishments. By doing this, Whitney was able to make the rules and principles of music visible in his films and find harmonious relationships between sound and image.

Whitney published a book in 1981 that focused specifically on music and the visual arts. He explained how digital computers could directly realize in animated form the same kind of harmonic movement found in music in ways that the Greeks had never even considered. Whitney hypothesized that Pythagorean harmony could be matched in the visual arts today. (Whitney 1981: 5)

[14] Procedural animation is a type of digital animation that creates animation automatically and in real time.

With technological advancements in recent decades, the canvas for these explorations broadened. Music visualization evolved from mere representation to experiential realms where the spectator is sometimes an active participant. As screens became ubiquitous, a paradigm shift occurred: the static visuals of yesteryears metamorphosed into dynamic, real-time visual symphonies, heralding the dawn of computational music visualization.

Given the vast spectrum of methodologies and mediums spanning across epochs, a comprehensive classification becomes imperative. While many academic discourses delve deep into specific modalities of music visualization, a unifying theoretical framework remains elusive. This brings us to the classification I propose, rooted in the computational and non-computational methods. It's imperative to note, however, that this classification does not purport to be a theoretical framework; rather, it is a proposed schema aimed at facilitating a more nuanced historical comprehension of visualizing music endeavors.

1.1.5 A proposed framework for visualizing musical experiences

In an endeavor to encapsulate the multifaceted realm of music visualization, I have conceptualized a classification (Figure.6) that attempts to capture the diverse interactions between music and its visual counterparts. Rooted in the principle that "music visualization refers to the process of representing sound and musical compositions in a visible and tangible format," this classification sheds light on both the traditional and contemporary experiences of visualization.

The classes "Static" and "Real-time" serve as an effective entry point, underlining the temporal characteristics of visual representations. Under the "Static" class, the juxtaposition of "Tactile and physical Synchronization" and "Screen-Based Synchronization" showcases the breadth of mediums available. Notably, the inclusion of categories such as "Visual Arts" emphasizes the longstanding tradition of visualizing music in the arts, from notations to paintings, graphic design, and etc., while the "Performing Arts" category acknowledges the innate visual nature of performing arts like dance and ballet as forms of music expressions.

On the other hand, the "Real-time" class addresses the burgeoning realm of dynamic visualizations. By distinguishing "Live music input" from "Pre-recorded music input," I have ensured that the classification is adjusted to both spontaneous live performances and meticulously crafted pre-recorded visualizations. The mention of "Interactive Experiences" is particularly related to computational methods, highlighting the potential for users to engage directly with the visualization.

However, like all classifications, this too may evolve over time. While it is expansive, future advancements in technology and art could introduce new mediums and forms of visualization that might necessitate further refinement. Yet, as it stands, this classification provides a vital framework for understanding and analyzing the myriad ways in which music can be visualized, bridging historical practices with contemporary innovations.

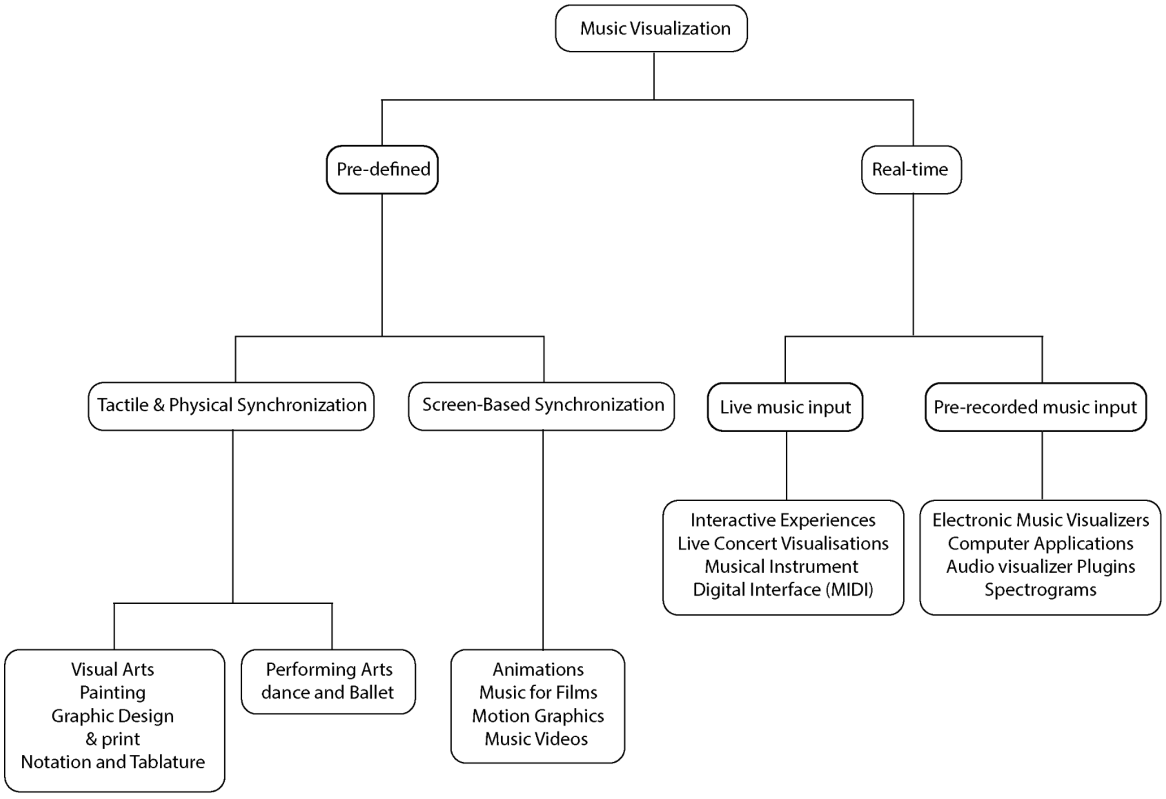


Figure.6 , A proposition Framework for visualizing musical experiences:
Tracing the Evolution from Traditional Forms to Contemporary Innovations.

1.2: The Traditional explorations of visualizing music

In light of my proposed framework, both tactile and physical synchronization under the "static" category, along with "Screen-Based Synchronization", can be considered a traditional form of visualizing music. Although these traditional explorations vividly represent the interaction between music and visuals, some scholars may contend they don't align with the conventional definitions of "Music visualization". Rather, they could be seen as ancillary visual narratives. Nevertheless, the distinction between traditional and contemporary visualization is becoming more ambiguous, highlighting the synergy of audio and visuals in today's media.

It's essential to recognize that these experiences enhance auditory experiences by intertwining sound with visual narratives or sensations. Building on this, many renowned artists have pushed the boundaries of these intertwined experiences, using visuals not just as complementary elements but as critical components that enhance the auditory sensation.

Salvador Dali's unique performance in which he draws the shape of a horse accompanied by live music displays the seamless marriage of auditory and visual experiences. Initially immersing himself in the sonic waves, Dali discerns the essence of the music before embarking on a transformative journey with his charcoal. His adept manipulation of pressure reflects the crescendos and diminuendos of the melody, while the tempo and rhythm manifest in the very cadence of his strokes akin to a dance choreographed to the symphony. Such an intimate connection with music propels Dali to metamorphose into an extension of the musical ensemble, inscribing his own visual notes onto the canvas. As the performance culminates, a majestic horse emerges, embodying Dali's sonic interpretation. This endeavor underscores the significance of transcending traditional artistic boundaries. It is pivotal to acknowledge that such ventures elevate auditory experiences by weaving them intricately with visual narratives or sensations. Over the ages, eminent visual artists have not merely treated music as adjuncts or ancillaries. Instead, they've championed music as a quintessential facet, amplifying the richness of auditory and visual sensations. (See drawing by Salvador Dali live with a band: Link, access Feb: 2023)

In the realm of cinema, sound has the remarkable ability to align seamlessly with a visual representation, starkly contrast with the expected, or deviate from conventional anticipation. As

noted by Bordwell and Thompson in their work (1985, p. 184), the soundtrack can serve to elucidate events depicted in an image, challenge them in a dramatic manner, or introduce an element of ambiguity.

In Michael Jackson's iconic music video for "Thriller" (1983), the song is masterfully augmented with synchronized choreography and a compelling narrative. The music's rhythm fluidly resonates with every dance move and gesture, suggesting the melody itself orchestrates the dancers' motions. The video's dark and atmospheric color palette heightens the eerie ambiance, harmoniously mirroring the song's genre and chilling lyrical content. (See The Thriller: Link, access Feb: 2023)

1.2.1 A personal experience

Building upon the previous discussion, my personal involvement in traditional forms of visualizing music has provided me with a firsthand perspective on the symbiotic relationship between sound and visuals. By immersing myself in the practical aspects of creating motion graphics and animation for a 2021 musical album; "The Black Fish", I experienced the delicate balance and interplay between auditory and visual elements.

During the development of motion graphics and animation for this album, my objective was to achieve a harmonious synthesis of auditory and visual dimensions, deploying a nuanced confluence of musical and visual elements that deeply engage the audience.

A specific section of the musical composition was judiciously selected for optimal impact. Central to this endeavor was the meticulous alignment of visual motifs to the inherent rhythmic cadence and tempo of the music. The outcome is a vibrant congruence, wherein the visual elements dynamically align with the ebbs and flows of the music. In instances of heightened musical intensity, the visual tempo accelerates, whereas tranquil musical segments are paralleled by a deliberate visual slowdown.

Highlighting the project's thematic core, a conscious decision was taken to employ a horizontal Artboard. This orientation is emblematic of the fish's journey within the expansive marine

milieu. Such a design facilitates a riveting depiction of the piscine journey, poetically portraying its exploration of the marine environment.

Moreover, the juxtaposition of textual elements and typography was intricately coordinated with the lateral undulation of the marine backdrop. This strategic alignment ensures a visual continuum where the textual progression emulates the rhythmic marine waves, culminating in a comprehensive and enveloping experience that underscores the narrative journey of "The Black Fish." (Figure. 7)

Figure.7: Frahani. M. (2022). Motion Graphic Promo for a classical music concert, Link, (access Oct 2023)

1.3 The contemporary explorations of visualizing music

In the contemporary discourse on music visualization, researchers have increasingly posited that current music visualization techniques align more closely with real-time input (Lima, et al., 2021). In recent times, the realm of visualizing music has seen innovative transformations, driven predominantly by the integration of cutting-edge technologies and artistic ventures.

As I illustrated in the provided diagram, there are two distinct categories delineated within the realm of real-time music visualization. The first category pertains to the live interaction between the music and either the performer or the end-user, encapsulating the immediate and dynamic experience. Technologies such as VR, AR, AI, MR, and etc. amplify this real-time immersion, letting users virtually "step into" music and engage with it spatially. This is displayed vividly in the realm of video gaming. To contextualize this notion, consider the case of "Guitar Hero" and "Beat Saber."

"Guitar Hero" (2005); which the new version released in (2015), revolutionized the realm of music-themed video games by masterfully integrating music visualization with a deeply interactive gameplay experience. Players visually interact with color-coded prompts that represent musical notes, translating into an intuitive understanding of the song's harmony and rhythm. The game's visual interface, characterized by vibrant color compositions, mirrors the energy and tempo of each track, immersing the player into the very essence of the song. Additionally, the adaptive settings and diverse song lengths in "Guitar Hero" cater to both beginners and experienced musicians, ensuring sustained engagement. This game seamlessly connects passive music with active creation, providing players with a comprehensive grasp of musical components like rhythm, tempo, and harmony in a visually engaging manner. Furthermore, the profound emotional connection one feels when crafting music is intrinsically linked to physical performance, emphasizing the game's focus on full-body involvement (Miller, 2012). (See Guitar Hero: Link, access Feb: 2023)

The "Beat Saber" (2018); is a VR rhythm game that offers an illuminating glimpse into the meticulous integration of musical tempo, rhythm, and interactive player gestures. At the heart of this rhythm game lies the harmonious synchronization between visual cues and auditory stimuli, demanding the player to exercise precise timing and coordination. The musical tempo, often energetic and fast-paced, challenges the player's reflexes and anticipates their movements in real-time. Rhythmic beats are the foundational pillars, dictating when and where the player should strike with their virtual sabers. It's worth noting that these beats aren't just arbitrarily positioned; they follow the intrinsic flow and cadence of the music, creating an immersive and rhythmically coherent experience.

Moreover, the gesture of the player, characterized by slashing movements, becomes an embodied response to the music. The dynamic interface, whereby the direction and speed of each slash correlate with musical nuances, fosters an active engagement that blurs the lines between passive listening and interactive participation. In essence, "Beat Saber" transforms music into a tactile landscape, inviting players to navigate and interact with melodies and beats unprecedentedly. (See Beat Saber: Link, access Feb: 2023)

The second category addresses the live synchronization of pre-recorded music with programmed visual elements, integrating predetermined auditory elements with responsive visual cues. Here, visuals are prepared, often computationally, to align with predetermined musical tracks. Examples of this category include music visualization applications and plugins embedded in audio players. Notable instances can be seen in platforms like iTunes Visualizer, which provides visualizations based on waveform analysis of the given music. However, a criticism that emerges in relation to these visualizers is their generalist approach. Most of them have been designed to cater to a broad range of musical genres and types. As a result, while they might be adept at detecting tempo and rhythm, the generated visuals often fail to resonate with the aesthetic essence and emotional depth of the music being played. I believe this generic representation can, at times, undermine the listener's experience, as the visuals might not harmoniously align with the deeper meaning or narrative of the song. In a world where tailored experiences are increasingly sought after, there's a pressing need for more nuanced and contextually aware visualizations that can capture and convey the unique spirit of each musical piece.

Amidst the generic music visualization tools that often fail to convey the depth and essence of songs, several software tools and platforms have endeavored to offer enhanced visual experiences. These tools, though not without their own limitations, have been at the forefront of shaping the realm of music visualization for digital platforms. Notable among these are visualization tools embedded within popular media players and standalone software. Let's delve into some of the prominent players in this field.Amidst the generic music visualization tools that often fail to convey the depth and essence of songs, several software tools and platforms have endeavored to offer enhanced visual experiences. These tools, though not without their own limitations, have been at the forefront of shaping the realm of music visualization for digital

platforms. Notable among these are visualization tools embedded within popular media players and standalone software. Let's delve into some of the prominent players in this field:
Windows Media Player: The default music player for Windows OS, Windows Media Player (WMP), came with various built-in visualizations that danced along to your music. (Figure.8).
The results can be seen below:

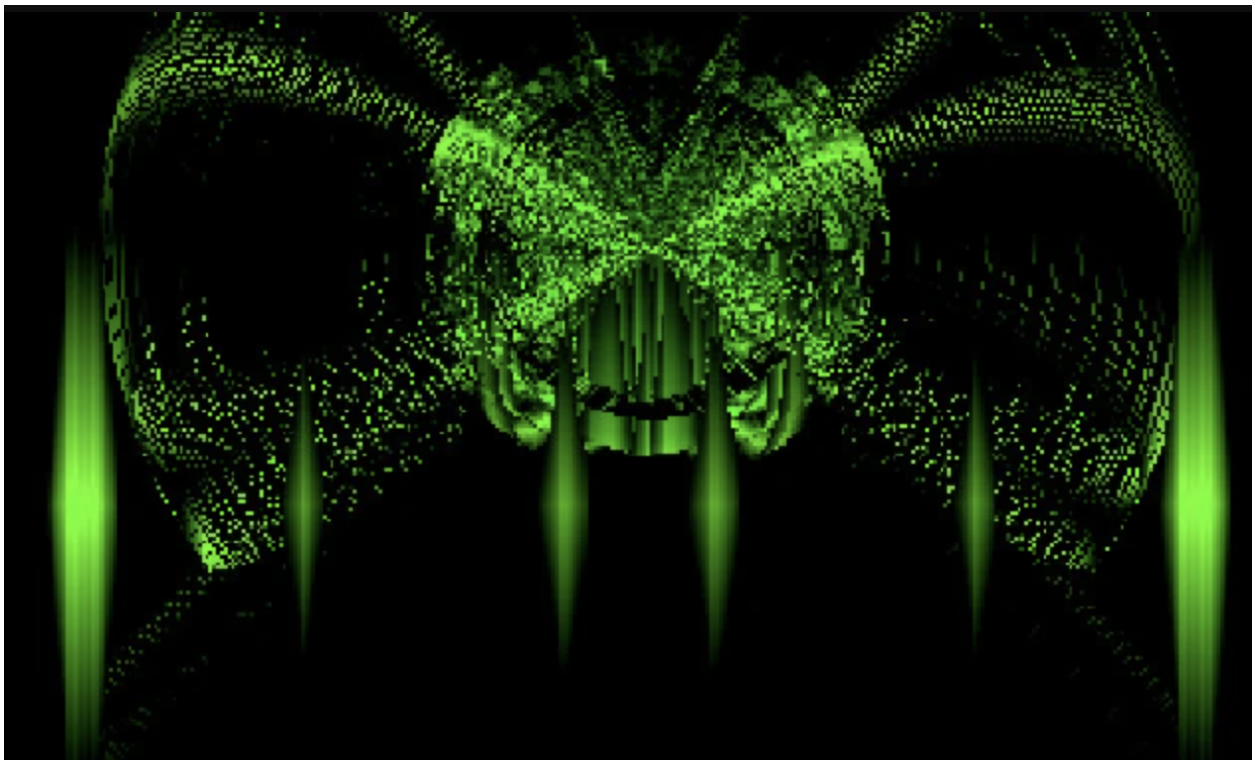


Figure. 8: Music Visualization Created by Trilogy Link, access Feb: 2023)

G-Force: A standalone music visualizer software that also had plugins available for popular media players like Winamp, iTunes, and Windows Media Player. G-Force is known for its rich visuals and vast array of user-customizable settings. (Figure. 9)
The results can be seen below:

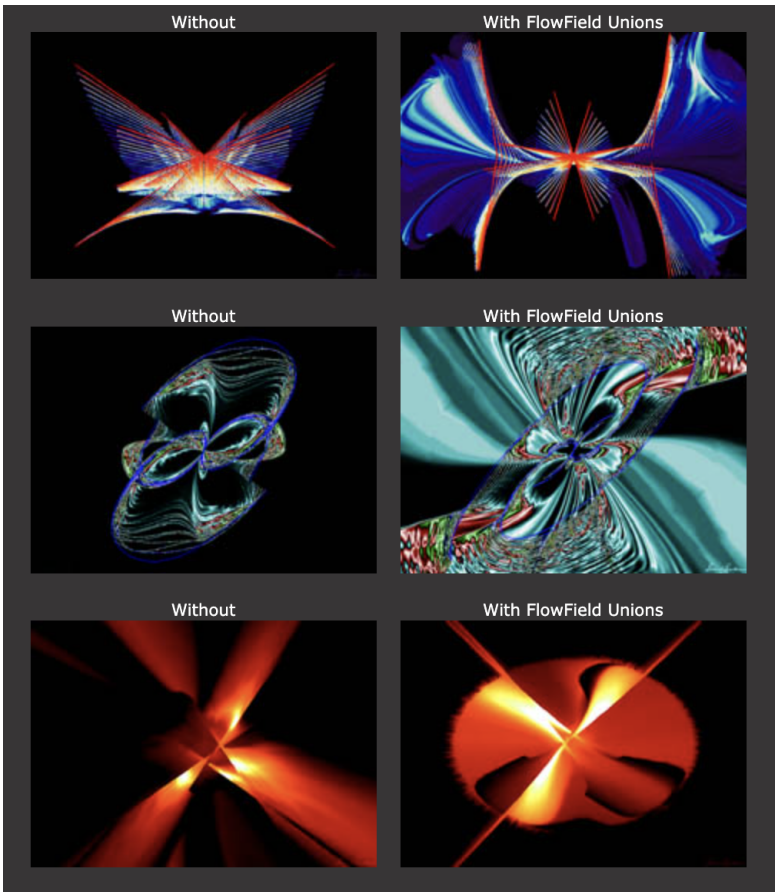


Figure. 9: Music Visualization Created by G-Force Link, access Sep: 2022)

MilkDrop: MilkDrop is a music visualization plugin initially developed for Winamp by Ryan Geiss. Ryan Geiss was the original creator of MilkDrop, but before that, he had created R4 for Winamp. Like R4, MilkDrop was known for its rich and dynamic visuals. (Figure. 10)

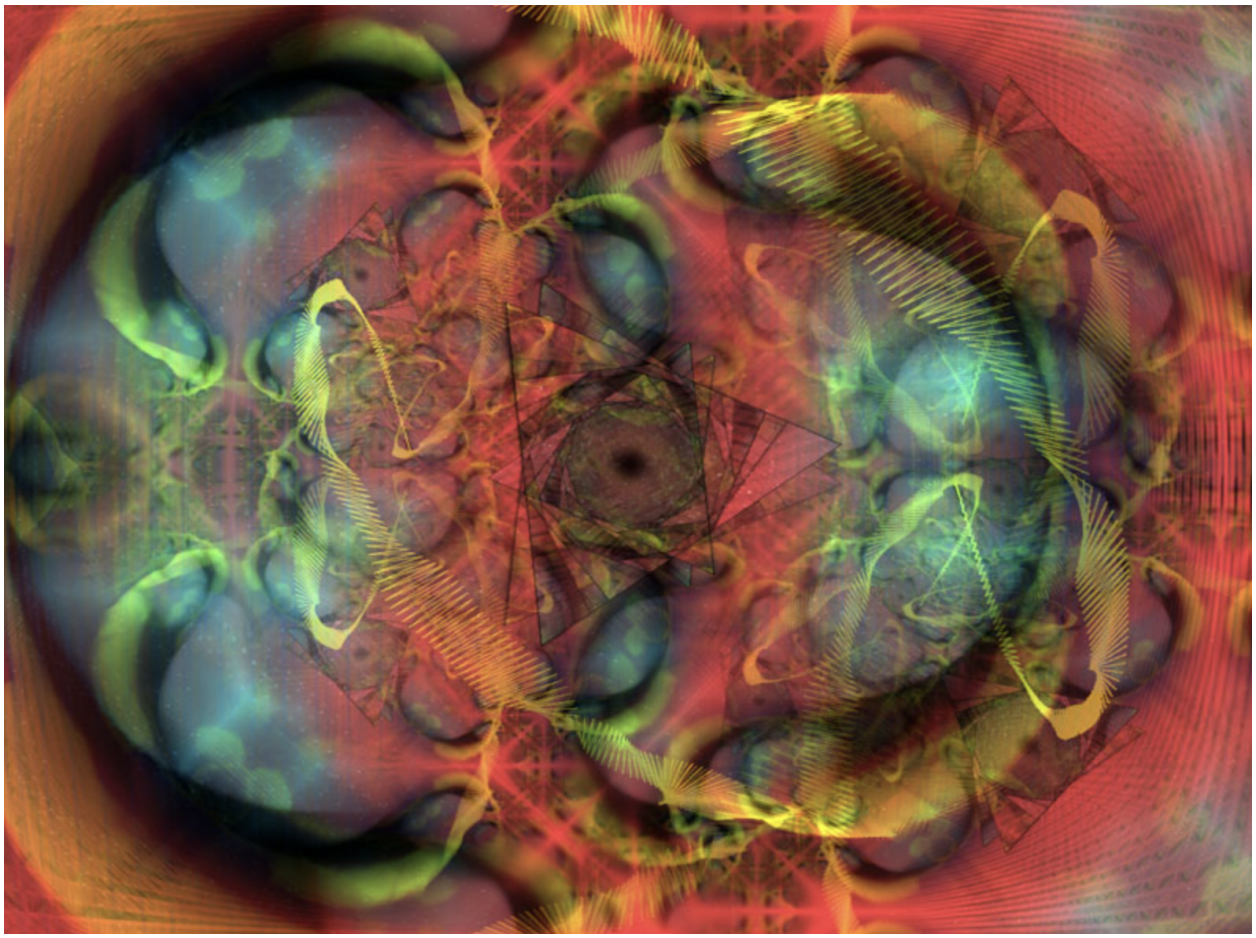


Figure. 10: Music Visualization Created by Ryan Geiss for Winamp (2001) Link, access Sep: 2022)

While some of these tools may be capable of detecting rhythmic or pitch variations, their visual output can often feel unpleasant, with motion lines and shapes weaving seemingly unpredictable patterns.

From an aesthetics perspective, one could argue that such visualizations, despite their attempt to capture the essence of the music, lack a deliberate aesthetic coherence.

The random patterns, although fascinating initially, can become overwhelming, even inducing visual exhaustion or headaches after prolonged exposure. This dissonance between the auditory and visual experiences fails to provide a holistic appreciation of the music and instead becomes a destructive element.

Interestingly, these chaotic and seemingly haphazard visualizations might find congruence with genres such as "Noise Music," "Noise Rock," or the jarring auditory experiences of "Speedcore". Such genres often embrace atonality, discord, and raw aggression, characteristics that these visualizers inadvertently mirror. Therefore, while these visualizations might be ill-suited for a melodious ballad, a symphony, a piece of classical music, or Persian traditional music, they could potentially be adopted as a visual partner to more abrasive musical forms or “Industrial Music”.

1.4 Generative approaches to music visualization

Generative art, an umbrella term that denotes artwork created through algorithmic processes, has seen various applications over the years. One of its particularly intriguing subsets is generative music visualization, which seeks to convert auditory experiences into visual representations using generative algorithms. Over time, several software languages and methods, like Processing with its Minim Library[15] and the more recent P5.JS, have become popular choices.
I concur with the notion that a significant distinction between generative music visualization and other generative art forms lies in the synchronization of the musical input with the generated visuals. While other generative art works might primarily focus on aesthetics or randomness, music visualizations mandate a direct and coherent correlation with the auditory input, thereby adding an additional layer of complexity and finesse to the generative process. During my investigation into algorithmic generative methods, I employed the p5.js library to explore the rich semantic aesthetics of Persian music in Persian visual culture.

[15] https://code.compartmental.net/minim/

Summary of part 1

To sum up, Chapter 1 on Music Visualization has provided a comprehensive overview of the field's historical evolution, definitions, and traditional and contemporary explorations. Throughout this chapter, I explored the intricate relationship between music and visual elements, shedding light on how they have converged throughout human history. I discussed the evolving nature of music visualization, driven by technological advancements and artistic innovation, from the early mechanical inventions like the Phonautograph to modern real-time interactive experiences. Additionally, I proposed a framework for categorizing music visualization experiences and understanding the diverse interactions between music and visuals.

As I progressed through this chapter, it became evident to me that music visualization is a dynamic and multifaceted field that continually adapts to new technologies and artistic expressions. The interplay between sound and visual elements, whether in traditional artistic endeavors or contemporary interactive experiences, enriched my perception of music and offered new dimensions to the auditory and visual arts. As I look forward, the exploration of music visualization promises to bring more innovative and immersive experiences, bridging the gap between the realms of sound and sight in exciting ways.

Part 2: From Perception to Artistic Expression

Introduction to Part 2

The intimate and intrinsic relationship between sound and image has been an enduring muse for both artists and scientists throughout history. At the nexus of this convergence lies the exploration of how we perceive, interpret, and interact with the world around us. Sound and vision, two of our most dominant senses, often meld in unexpected ways to create richer, more textured experiences. This part delves into the multi-layered concept of sound and visual interplay, beginning with understanding the relations between image and sound, touching upon the phenomena of synesthesia, and examining the potential for artists to evoke sensory perceptions akin to synesthesia in their audiences.

2.1 The Interaction between Images and Sounds

The interaction between images and sounds represents a fundamental aspect of art creation, playing a pivotal role in shaping the aesthetic and emotional experience of the audience. Understanding this interaction is essential for artists and creators as it enables them to harness the full potential of both visual and auditory elements to evoke the senses, convey messages, and have a profound impact on the audience.

In the domain of visual art, where images and sounds converge to create multidimensional experiences, there exists a multitude of techniques that artists and designers can employ to amplify the interaction between these two sensory realms. These techniques and personal experiences serve as vital tools in the artist's palette, offering an expansive range of possibilities for enriching the artistic discourse.

Here are some examples of techniques that designers can use to amplify the interaction between images and sounds, further enriching the artistic discourse:

Aesthetic Synergy:

Artists have long recognized the inherent synergy between images and sounds in creating a compelling aesthetic experience. This synergy, often referred to as "synesthesia," occurs when the combination of visual and auditory elements enhances the emotional and sensory impact of an artwork. This concept has been extensively explored in the field of multimedia art. For example, in his seminal work "Space, Time and Architecture," Giedion (1941) discusses how the design of physical spaces, which inherently involve both visual and auditory stimuli, can create a profound aesthetic experience. Similarly, avant-garde artists like Wassily Kandinsky have delved into the relationship between color and sound, exploring how specific hues and tones can evoke certain emotional responses (Kandinsky, 1910).

Message Conveyance:

Understanding the interaction between images and sounds is equally crucial for conveying messages in art. Visual and auditory elements can complement each other, reinforcing the intended message or narrative. A classic example is in film, where the synchronization of visuals and music serves to heighten the emotional impact of a scene. The work of filmmaker Sergei Eisenstein, particularly his concept of "montage of attractions," exemplifies how the combination of contrasting images and sounds can convey powerful messages (Eisenstein, 1942). Furthermore, artists often use the interaction between images and sounds to subvert or challenge traditional narratives. The Surrealist movement, for instance, sought to disrupt conventional understanding by juxtaposing seemingly unrelated visual and auditory elements. Salvador Dalí's painting "Persistence of Memory" (1931) and the accompanying soundtrack "Un Chien Andalou" (1929) by Luis Buñuel and Salvador Dalí exemplify this approach, pushing the boundaries of how audiences perceive and interpret art (Matthews, 2002).

Sensory Elicitation:

To create art that resonates with the audience on a sensory level, understanding both visual and auditory components is imperative. The neuroscientific study by Cytowic (2002) on synesthesia provides insights into how sensory perception is interconnected, suggesting that experiences involving multiple senses are more immersive and emotionally engaging. This principle is relevant to art, where the goal is often to immerse the audience in a sensory-rich environment.

For instance, the immersive sound and light installations of contemporary artist Olafur Eliasson, such as "The Weather Project" (2003), demonstrate how the interaction between images and sounds can evoke profound sensory experiences (Eliasson, 2003).

2.1.1 A Personal Journey of Multisensory Expression in Visual art and music

Throughout my career as a graphic designer and visual artist, I've had the privilege of collaborating on more than a hundred visual artworks that intertwine with music, encompassing various artistic mediums. Each project has not only posed a unique creative challenge but also offered an invaluable opportunity for self-expression. A consistent guiding principle in my work has been the desire to transcend the confines of mere visual aesthetics, aiming instead to plunge into the profound emotional and sensory dimensions of art, particularly when engaged in music-related endeavors. I ardently maintain the belief that visual art should not be confined solely to the realm of sight but should be an experience that can be both heard and felt. This belief serves as the cornerstone of my creative approach, shaping the essence of my artistic journey. As Kandinsky aptly noted, Color is the keyboard, the eyes are the harmonies, the soul is the piano with many strings.' It is in the fusion of these harmonies that art achieves its greatest resonance. (Kandinsky, 1910)

Continuing, I will showcase a selection of my works that were published over various years, during which I experimented with the fusion of visual imagery and musical expressions. My aim was to create a profound sense of understanding and appreciation for these artistic compositions.

Figure. 11: Farahani, M. (2022). *Illustration for CD cover: Pen and Ink on cardboard*. An abstract figure of a Setar player, with cascading colors and brush strokes capturing the melodies in flight and the motion of the hand, Mahoor Publication. Reference: Link

Figure. 12: Farahani, M. (2022). *Illustration for CD cover: Pen and Ink on cardboard*. An abstract figure of a Tar player, with cascading colors and brush strokes capturing the melodies in flight and the motion of the hand, Mahoor Publication. Reference: Link

In composing the cover designs for these two CDs (Figure. 11 & Figure. 12), I utilized the art of illustration with a specific focus on evoking the essence of instrumental music. The figure of the instrumentalist I created, wielding a Persian calligraphy pen, assumes an informal structure characterized by a lack of intricate details. Lines and textures intentionally overlap, mirroring the interplay of light and shadow, much akin to the nuanced movements of an instrumentalist during their performance. My intention was to convey the dynamic contrast between strong and weak movements, reminiscent of the way an instrumentalist manipulates their instrument. I sought to capture the essence of this manipulation by using brushwork to suggest the motion and sound of a plectrum or pick held within the hand of the instrumentalist. Additionally, I integrated the essence and rhythm of music into the design, allowing them to traverse the entire frame. These rhythms meld seamlessly with the composition, creating an abstract arrangement that parallels the complexity and harmony found within a musical composition.

In these artworks, I aimed to transcend conventional artistic expression and expand beyond the confines of visual aesthetics. My goal was to forge a deep connection with the viewer's senses, eliciting a symphony of emotions. By seamlessly merging the realms of the visual and auditory, these creations acquire a multi-sensory essence, greatly enhancing their capacity to evoke profound and heartfelt responses.

In the subsequent design (Figure. 13), I ventured into the realm of complete abstraction with heightened boldness. At the heart of the composition, an Oud player takes center stage, enveloped by a vibrant array of colors reminiscent of the abstract expressionist movement, notably drawing parallels to the late works of Jackson Pollock. It not only captivates the viewer visually but also engages them emotionally by translating the musician's auditory expressions into a visual language.

Figure.13: Farahani, M. (2022). *Illustration for CD cover: brush and Ink on cardboard*. An abstract representation of an Oud player, where dispersed colors encapsulate the soaring melodies, Mahoor Publication. Reference: Link

The musical notes suspended in the air add a dynamic dimension to the artwork. These notes, clearly in flight, traverse the composition, intertwining, and forming harmonious patterns. Their silent pauses and subsequent resurgence mirror the ebb and flow of the musician's performance, evoking a profound emotional atmosphere. The interaction between image and music in this design creates a multisensory experience, where the visual and auditory elements harmonize, inviting the audience to immerse themselves in the synthesis of art forms.

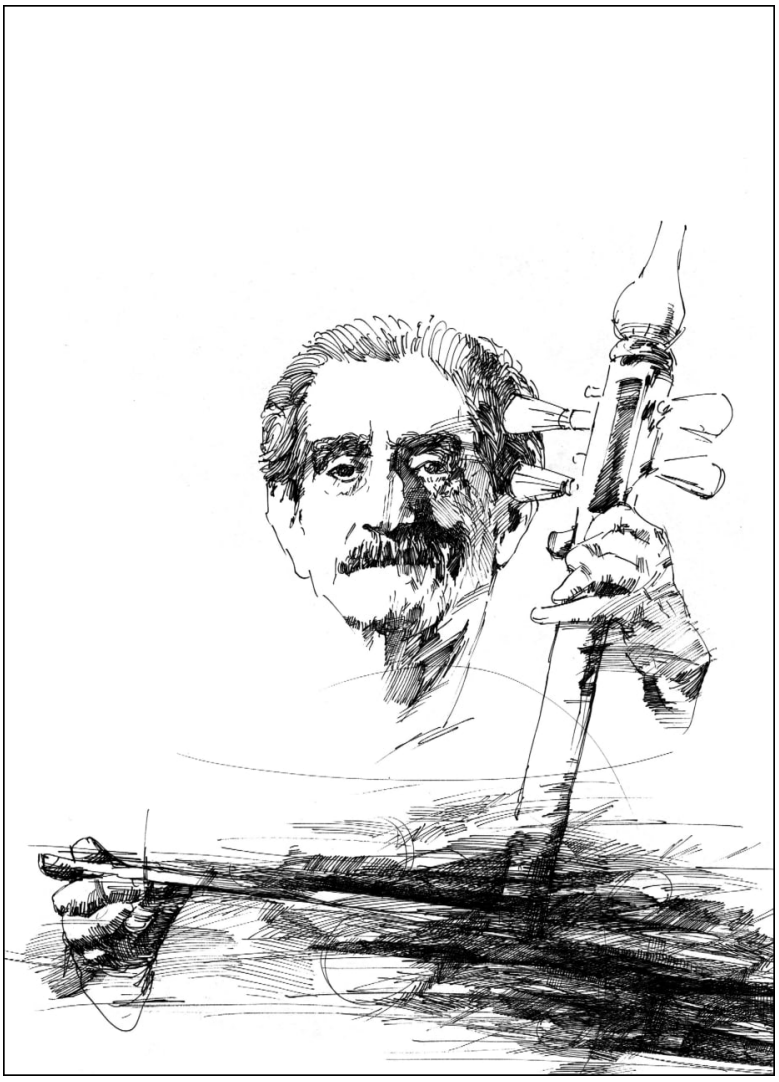


Figure 14. Farahani, M. (2021). *Illustration for book cover: metal pen and Ink on paper*. Emulate the raspy yet harmoniously natural resonance of the Kemancheh, Mahoor Publication. Reference: Link

In this illustration, I have endeavored to encapsulate the tonal quality of the Persian Kemancheh, an instrument whose sound resonates deeply within the cultural fabric of the region.
Using cross hatching, I've sought to mimic the scratching yet harmoniously organic sound of the Kemancheh. Much like the rustling of dry leaves in autumn, the sound is neither completely smooth nor wholly jagged, but a blend of both, echoing nature's melodies. The rough, erratic lines and strokes enveloping the musician and the Kemancheh serve a dual purpose - they not

only provide a sense of motion and energy but also allude to the raw, unrefined tonal output of the instrument. (Figure.14)

In summary, through this illustration, I've aimed to translate the auditory experience of the Kemancheh into a visual one, bringing to life its unique sound and the profound connection between the images and sound.

Multisensory expression represents a pivotal intersection in the domains of visual art and music. As scholars like Bartolome (2021) have argued, the intertwining of auditory and visual stimuli not only provides a richer sensory experience but also offers profound insights into the cognitive processing of artistic mediums. By exploring the synesthetic relationships between color, shape, and sound, artists and musicians alike have the potential to craft immersive experiences that challenge traditional boundaries of perception. This multidimensional approach to artistry provides a platform to explore the interconnectedness of our senses and further highlights the holistic nature of human sensory perception. (Bartolome et al., 2021)

2.2 Visual and Musical Communication as a Form of Expression

Music and visual arts indeed have the capacity to elicit unique and separate emotional responses in their audiences. Recent empirical research (2017) has revealed stark differences in how "pleasure" is conceptualized and studied in music and visual art. Music research, rooted in emotion psychology, emphasizes direct and intrinsic pleasure, while visual art research, influenced by neuroaesthetics, sees pleasure as more indirect and context-dependent within the broader aesthetic experience. These distinctions reflect the diverse traditions that shape the study of these two art forms. The study suggests the need for a multimodal perspective that integrates "music" and "visual art" research, exploring modality-specific emotional responses to enhance our understanding of enjoyment both conceptually and sensorial. (Tiihonen et al., 2017)

As the authors suggest, by combining these genres of art, we can effectively evoke a wide array of sensations and emotions, tapping into the diverse feelings and experiences that music and visual art have to offer.

2.3 Synesthesia in Arts

Within the art world, synesthetic experiences have been instrumental in guiding artists to create pieces that challenge conventional sensory boundaries. Brang (2011) postulated that the enhanced processing of sensory information in synesthetes suggests a potential evolutionary advantage, hinting at synesthesia's latent capacity for deeper sensory appreciation. (Brang et al., 2011) Notably, renowned artists, such as Wassily Kandinsky, explored and employed synesthetic principles, aiming to create artworks where colors and shapes evoked specific auditory experiences, merging the visual and auditory realms into a cohesive sensory experience. Such endeavors in art not only champion the convergence of sensory modalities but also pave the way for enriched, immersive artistic expressions that transcend traditional confines.

However, while the concept of synesthesia in art is celebrated for its ability to produce multisensory masterpieces, it's essential to approach it with a degree of circumspection. Chiou (2014) argued that inducing stimuli and synesthetic experiences may not always occur harmoniously within the same modality (Chiou. et al., 2014). Therefore, while artists may aim to capture the essence of synesthetic perceptions, achieving a genuine and universally resonant synesthetic experience for the audience remains a challenging endeavor, demanding a profound understanding of the intricate nuances of sensory interplay.

2.4 The synergy between auditory and visual stimuli

The engagement of images with music in the realm of music visualization is a complex interplay of auditory and visual stimuli that can evoke a heightened perception of music. This synergy between the two modalities offers a rich multisensory experience for audiences and has always been a subject of scholarly research.

The combination of visual images with music taps into the phenomenon of cross-modal perception, where one sensory modality influences another. This cross-modal interaction can enhance the audience's perception of the music by providing additional sensory input, creating a holistic experience (Glasser, S. 2023).

As (Bragança et al., 2015) explain visual imagery can convey emotional content that complements the mood of the music and a piece of music (sound event) could be considered sweet (sense of taste), rough (tactile), or brilliant (visual). For example, serene visuals may enhance the perception of calming music, while dynamic and vibrant visuals can amplify the energy of the music, fostering an emotional connection (Bragança et al., 2015).
Moreover, Music visualization can aim to induce synesthetic experiences, where visual stimuli trigger sensory perceptions related to music. This can involve associating specific colors, shapes, or movements with musical elements, creating a synesthetic fusion of senses (Curwen, 2023).
Therefore, the engagement of images with music in music visualization creates a synergistic relationship between auditory and visual stimuli, offering audiences a richer and more immersive perception of the music.

2.5 Wassily Kandinsky's Music Visualization concept

Wassily Kandinsky, the Russian abstract artist, developed a concept known as "music visualization" in the early 20th century. In his book "On the Spiritual in Art" (1911), Wassily Kandinsky did not directly use the term "music visualization." The concept of music visualization is a term that has been applied by others to describe Kandinsky's ideas and theories regarding the relationship between music and visual art.
It's important to clarify that "music visualization" is not a formal theory. Wassily Kandinsky's writings do not offer a comprehensive theory of music visualization and synesthesia, despite the use of the term "theory" by some scholars (Short, 2009) in their work; instead, they can be viewed as a theoretical exploration. In scholarly terms, a "theory" is a systematic and comprehensive framework developed through rigorous research, analysis, and empirical evidence to understand, explain, or predict phenomena. Kandinsky's work is primarily associated with the concept that he recognized a profound connection between “music” and “visual art”, where he aimed to capture the essence of music in visual form.
Kandinsky believed in the expressive power of color and form in painting and often made connections between the emotional and spiritual qualities of music and the visual elements in his

artworks. He discussed about the connection between visual art and music, seeing them as parallel forms of expression that could evoke similar emotional responses in the viewer and listener.

Wassily Kandinsky in "On the Spiritual in Art," discusses the challenges of formulating a complete theory or establishing a firm artistic basis in the modern conception of harmony. Kandinsky acknowledges attempts made in the past, drawing a parallel with music and citing Henri Ravel's statement that the laws of harmony for painting and music are the same. However, Kandinsky cautions against hasty claims that there can be no definite rules or general principles in painting, as such assertions could lead to academicism. (Kandinsky, 80:1911)

Kandinsky highlights the early stages of painting's emancipation from a direct dependency on nature and the use of color and form as inner agents, often employed subconsciously. He mentions the historical use of geometric form in ancient art, particularly by the Persians, but emphasizes that building on a purely spiritual basis is a gradual and sometimes aimless process. He suggests that painters need to train not only their eyes but also their souls to perceive and utilize color as a definite power in their creations. (Kandinsky, 80-81:1911)

Given that music and visual art share psychological and spiritual qualities, both art forms can tap into the emotional and spiritual aspects of human experience through the use of abstract forms, colors, and compositions.

In music, certain melodies, harmonies, rhythms, tempos and dynamics can evoke a wide range of emotions and create a deep emotional impact on the listener. Similarly, in visual art, the choice of colors, shapes, lines, and their compositions can evoke specific moods, sensations, and spiritual responses. Kandinsky saw these elements as carriers of psychological and spiritual qualities that have the power to move and resonate with the audience on a deep level. By exploring the parallels between music and visual art he aimed to emphasize the non-representational aspects of art and its potential to communicate emotions and spiritual experiences directly, transcending the need for recognizable subject matter.

While Kandinsky discussed the parallels between music and visual art in his book, he did not extensively open and analyze his idea. His focus primarily revolved around the spiritual and

emotional aspects of art, exploring the potential for color, form, and composition to evoke inner experiences and transcend mere representation.

Kandinsky's viewpoint can be summed up in his statement:

> *"As no 'dissonant notes' exist in music, nor in painting 'inharmony,' in these two art expressions every sound, whether harmony or discord, is beautiful (appropriate) if it results from inner need." (Kandinsky, 86: 1911)*

The quote suggests that in the realms of music and painting, there is no concept of dissonance or inharmony in the traditional sense. According to Kandinsky, every sound or visual element, whether harmonious or discordant, can be considered beautiful and appropriate if it arises from an inner necessity or purpose. However, it's important to note that Kandinsky's perspective should not be interpreted as a complete dismissal of rules and guidelines in art. While he emphasizes the freedom of expression and the importance of inner need, Kandinsky also acknowledges the need for training, learning, and the development of skills. His intention is not to advocate for a complete abandonment of artistic principles but rather to highlight the significance of personal expression and the exploration of inner motivations in art creation.

Kandinsky's view had a significant influence on the development of abstract art, particularly in the movement known as "abstract expressionism." Artists inspired by Kandinsky's ideas sought to create visual compositions that conveyed emotions, sensations, and spiritual experiences through non-representational forms, colors, and brushwork.

Overall, Wassily Kandinsky's music visualization concept proposed a connection between music and visual art, suggesting that abstract visual compositions could evoke emotional and spiritual responses in a manner similar to music's effect on the listener. His ideas challenged traditional notions of representation and paved the way for the development of abstract art movements.

Summary of part 2

In wrapping up Part 2, I've delved deep into the intricate relationship between the visual and auditory dimensions. Right from the start, I've established the foundational bond between images and sounds, drawing inspiration from my personal exploration into multisensory expression. I've closely examined the realms of visual and musical communication, seeing them as distinct yet interwoven forms of art. I've also delved into the realm of synesthesia, exploring its presence in art and its significance among renowned artists. I've been interested in the possibility of evoking synesthetic feelings in a wider audience and have tried to discuss the possibility of mixed emotions in others as an alternative technique. I've highlighted the harmonious interplay between sound and sight, emphasizing the immense potential of music visualization, deeply inspired by Wassily Kandinsky's groundbreaking ideas. Throughout this section, I've emphasized the endless possibilities and intricate nature of blending sight and sound. This has solidified my belief that intertwining our senses, especially hearing and sight, not only enhances our artistic journey but also reshapes our perspectives, pushing us to explore beyond the conventional limits of sensory experience and creative expression.

Part 3: Persian Art

Introduction to part 3

Persian art, characterized by its intricate amalgamation of meanings with structures and narratives, finds its origins in the ancient civilizations that flourished on the Iranian plateau millennia ago. Central to a comprehensive grasp of Persian art is an exploration of its epistemological underpinnings, which concern the genesis, characteristics, methodologies, and boundaries of human comprehension regarding this artistic tradition. In this section, instead of delving deeply into the epistemological underpinnings of Persian art and its cultural significance, I will provide a brief exploration of the interconnected semantics and frameworks that unite Persian calligraphy with Persian music. This examination aims to offer insight into why I have chosen Persian Nastaliq letters for the visual components of my work.

3.1 The Symbiotic Relationship Between Persian Music and Persian Calligraphy

In ancient societies, such as Iran, various forms of artistic expression did not exist in isolation; instead, they served as manifestations of shared philosophical and ontological foundations. The interaction between woven motifs in Persian carpets, the dialogues among lines, shapes, and forms in miniature paintings, the meaningful dance of light and shadow in architectural marvels, poetic calligraphy, and the spiritual essence of Persian music not only served aesthetic purposes but also functioned as windows into the deeper spiritual and intellectual realms of the Iranian people in the past (During,1982). Indeed, their interdependence was exceptionally strong, particularly in the symbiotic relationship between music and calligraphy. Over the centuries, this symbiotic connection has grown even more profound.

3.2 Persian music

Iran is a culturally diverse nation characterized by a mosaic of eight prominent ethnic groups and their respective ethnic lineages. Each of these ethnic communities boasts a rich historical heritage, distinct cultural expressions, profound literary traditions, intricate art forms, and unique musical genres (Kazemi, 2002). In this discussion, the term "Persian music" refers to the musical heritage that pertains specifically to the Persian populace, who constitute one of Iran's largest ethnic groups and are primarily speakers of the Persian language. Within the broader Iranian context, this musical genre is commonly referred to as "Persian traditional music." Within the scope of this discussion, the examination of Persian music's structural intricacies and its musical system are not focal points. However, it is imperative to acknowledge that the ontological framework underpinning this musical genre is intricately interwoven with the perspectives and philosophies of ancient Iranians. These foundational principles, dating back to antiquity, have been preserved and conveyed to contemporary generations through the conduit of classical literature and the poetic verses authored by Iranian old poets.

The nexus between Persian traditional music and Persian calligraphy resides in their shared reliance on poetry and literature. These artistic domains converge in their capacity to communicate ideas and sentiments to their audience by means of Persian poetry. To illustrate this connection more clearly in the realm of Iranian music, vocalists employ techniques such as the elongation of musical notes or the utilization of Tahrir (musical ornaments) to underscore specific conceptual nuances, akin to the practice of calligraphers who employ distinctive alterations to the form of letters to convey similar emphases. In the wake of the Industrial Revolution and the subsequent wave of modernization that characterized the past century, a transformation was witnessed not only in the realm of traditional Iranian poetry but also within the domain of Iranian calligraphy. The evolution of Persian calligraphy underwent significant changes in both its semantic and aesthetic aspects, primarily driven by the introduction of machine typesetting technologies. Simultaneously, the nature of music underwent a significant shift, with a discernible departure from its foundational essence.

3.3 Persian Calligraphy

Numerous scholarly investigations have extensively examined Persian calligraphy, rendering it a well-established subject within academic discourse. In this context, my aim is not to reiterate or criticize existing research but rather to leverage this opportunity to expound upon my perspective regarding the categorization of Persian calligraphy within the purview of Islamic calligraphy. It is noteworthy that previous scholarship has often categorized Persian calligraphy as an integral component of Islamic calligraphy, occasionally characterizing Persian calligraphy exclusively as Islamic calligraphy. Regardless of this prevailing categorization, I intend to contribute a nuanced viewpoint that acknowledges the interconnectedness of Persian calligraphy with Persian music and Persian aesthetics while also recognizing its unique identity and cultural significance beyond the confines of Islamic art.

The distinction between Persian calligraphy and Islamic calligraphy is rooted in their ontological underpinnings, which form the foundational infrastructure that sets them apart as distinct art forms. In academic discourse, ontology refers to the philosophical study of the nature of existence and reality, and when applied to calligraphy, it delves into the fundamental principles that govern these artistic traditions.

Persian calligraphy, deeply interwoven with the rich fabric of Persian culture and history, showcases an ontological structure that places a profound emphasis on Persian literature. Similarly, the bedrock of Persian music finds its origins deeply rooted in the timeless realm of ancient Persian literature. It embodies the essence of Persian identity, drawing from a diverse palette of historical influences, literature, and aesthetics. Persian calligraphy is characterized by its diverse range of scripts, each with its unique expressive qualities, reflecting the Persian identity.

Conversely, Islamic calligraphy is underpinned by an ontological framework rooted in the religious and spiritual aspects of Islam. It serves as a conduit for the transmission of Islamic scripture and spirituality. The primary focus of Islamic calligraphy is the precise representation of sacred texts, and it adheres to specific script styles that have evolved to enhance the legibility and reverence of the written word.

This ontological divergence underscores the contrasting objectives of these calligraphic traditions. Persian calligraphy eloquently represents the collective consciousness of Iranians, intricately interweaving their profound cultural heritage, steeped in Persian literature, into a captivating and expressive artistic form, while Islamic calligraphy is inherently tied to the religious and spiritual dimensions of Islam.

3.3.1 Siyāh Mashq

Siyāh Mashq, which can be literally translated as 'Black Practice', is a distinct form within Persian Calligraphy. This term originates from the traditional practices of Iranian old calligraphers and scribes. Before embarking on their main work or inscribing a treatise, they would engage in a warm-up exercise. This involved repeatedly writing letters in a manner that they overlapped, creating intricate and mesmerizing patterns. (Ekhtiar, 2006)
In this particular form of calligraphy, calligraphers endeavor to craft a harmonious composition by thoughtfully arranging letters. Siyāh Mashq focuses less on legibility and more on the meticulous construction of the page, emphasizing the equilibrium between black and white elements. As such, Siyāh Mashq can be perceived as the zenith of pure calligraphic artistry, where the primary emphasis lies in its aesthetic appeal and inventiveness rather than its literary content. This unique form of writing, boasting several centuries of history, comes in an array of exquisite styles. In traditional Siyāh Mashq, letters and words are repetitively inscribed. While in some variants, groups of Siyāh Mashq may be discernible, the calligrapher typically does not adhere to a specific narrative or theme in this art form. (Figure.15 & 16)

Figure.15: Esfahani. M. Gh. (19th century). The diagonal compositions of Siyāh Mashq.

Reference: National Library of Iran.

Figure.16 : Unknown artist. (19th century). Siyāh Mashq Calligraphy based on Nasta'liq script. Reference: Library of Congress African and Middle Eastern Division, Washington, D.C. 20540, USA.

3.4 The dialogue between Persian Calligraphy and Persian Music

The intertwining discourse between Persian Calligraphy and Persian Music serves as a captivating exploration of the profound connections that underlie these two art forms. This exploration unfolds like a mesmerizing duet, where the visual realm and the auditory realm converge in their power to convey emotions, ideas, and common cultural values. In the realm of Persian music, vocalists skillfully employ techniques akin to the practiced hands of calligraphers, using musical notes and Tahrir (musical ornaments) to convey nuanced emotions and conceptual depths. On the other hand, traditional calligraphers seek to control the movements of the reed pen with the rhythm and melody of Persian music.

Maestro Mohammadreza Shajarian, a notable figure in the realm of Persian music, said: "As a vocalist, refrain from extending a musical note beyond twice within a verse! Similarly, traditional calligraphers of the past upheld the notion that the Keshideh[16] line (flourish) should not be employed more than twice in a single verse"(Shajarian, access: Feb 2023, Link) This emphasizes the importance of balance, rhythm, and precision in conveying emotions and ideas. In another example, One of my vocal maestros used to say, "Try to harmonize the lightness and darkness of your sound, akin to the bright and dark shades of ink in a piece of calligraphy. Sing with both brightness and softness at different times."

In the traditions of Persian calligraphy, a thick line or stroke is often referred to as "heavy" and a thin line or stroke in calligraphy is described simply as "light." In today's Persian calligraphy terminology, "heavy" or "light" is not a standard term or concept. However, this term is being used informally or colloquially. In Persian music also, a "heavy note" and "light note" or "dark sound" and "bright sound" is not a standard or usual term among the new generation in Iran. Because, in music theory, notes are typically described by their duration (e.g., whole note, half note, quarter note) or pitch (e.g., C, D, E) rather than being categorized as "heavy" or "light." However, these terms are being used informally or colloquially by old music masters to describe a modal or musical characteristic.

---

[16] . A Keshideh is an elongated, horizontal stroke that connects two characters or extends a character, primarily to emphasize a word or enhance its visual appearance.

The purpose of this brief discussion was to highlight the existence of a meaningful and reasonable dialogue between Persian Calligraphy and Persian Music, or, in a broader context, to emphasize the aesthetic interplay between visual and auditory elements within Persian art. This shared philosophy reflects the enduring cultural values that have shaped the artistic heritage of Iran, demonstrating how disciplines as distinct as music and calligraphy can share a harmonious resonance in the realm of creativity and expression.

3.5 Calligraphic Painting

"Calligraphic Painting" or "Calligraphy-Painting" in Iran is a unique and innovative art genre that combines elements of traditional Persian calligraphy with contemporary painting techniques. It involves the fusion of calligraphy, illustration, and painting to create visually captivating compositions that often transcend literal meaning and emphasize visual aesthetics.

The fusion of calligraphy, illustration, and painting has a rich and enduring history in Iran. The evolution of "Calligraphic Painting" in Iran reflects an innovative convergence of tradition and modernity, signaling a dynamic shift in artistic approach over time. To appreciate the modern roots of "Calligraphic Painting", we must look at the traditional composition of Siyāh Mashq. Calligraphic Painting, in essence, extends and reinterprets the fundamental principles of Siyāh Mashq, building upon a legacy that spans centuries and showcasing the ongoing evolution of this artistic genre.

Within the realm of "Calligraphic Painting", contemporary Iranian artists have embarked on a transformative journey, embracing this innovative art genre. It serves as a compelling bridge connecting the rich heritage of Persian calligraphy with the expressive freedom afforded by contemporary painting. These artists have ventured beyond traditional confines such as the reed pen and paper, embracing modern tools like handmade strokes, brushes, putty knives, and unconventional surfaces such as canvas, cardboard, and wood. This departure from conventional tools and materials of Persian calligraphy enables greater experimentation and artistic expression.

Within the realm of "Calligraphic Painting", a cadre of pioneering artists has emerged in the recent century. Each has contributed a unique perspective and approach to this burgeoning art form. Reza Mafi, recognized as one of the pioneers in the realm of “Calligraphic Painting”, brought a unique perspective to this burgeoning art form. A classically trained calligrapher, Mafi transitioned to large-scale oil painting as a means of abstract expression, skillfully incorporating calligraphic forms into his artwork (Figure.17).

Figure. 17: Mafi. R., (1974), Calligraphic Painting, oil on canvas,
Reference: Private collection.

Faramarz Pil Aram's oeuvre of Calligraphic Paintings is characterized by exquisite texture and composition, deliberately shifting the focus from content to form and rhythm. Pil Aram artfully combines visual balances and rhythms with repetitive patterns of words and letters, resulting in compositions distinguished by the striking interplay between black and brown ink on the canvas.[17] Charles Hossein Zenderoudi explores a stylized form of calligraphy reminiscent of Siyāh Mashq pages in his artistic endeavors. His paintings often feature abstract calligraphy that transcends literal meaning. Zendeh Roodi's compositions are rhythmic, employing a kaleidoscope of colors and techniques, such as oil on canvas—an unconventional choice for traditional calligraphy.[18] His works skillfully capture the rhythmic motions of calligraphers as they manipulate the reed pen to achieve their desired shapes and thickness (Figure.18).

On the other hand, Mohammad Ehsaie, another luminary in the realm of Calligraphic Painting, weaves together tradition and modernity in his creations. Ehsaie's artistry involves experimentation with the placement of letters, elevating their aesthetic impact above their literal content. His works echo the essence of Siyāh Mashq, with words and phrases flowing onto the canvas like rhythmic mantras, captivating viewers with the hidden onomatopoeic forces embedded within the composition.

In this milieu of artistic innovation, "Calligraphic Painting" serves as a testament to the enduring influence of tradition on contemporary Iranian art. As this art form continues to evolve and flourish, it reaffirms the profound capacity of abstraction to transcend cultural boundaries and resonate with audiences on a universal level. "Calligraphic Painting" not only serves as an artistic expression but also as a cultural bridge, connecting the past with the present and challenging conventional boundaries of artistic expression. This synthesis of tradition and modernity, as embodied in Calligraphic Painting, also invites consideration of its place within the broader context of Western abstract art, particularly abstract expressionism. While shared elements prioritize visual and emotional impact over literal representation, the nuances in cultural context and techniques provide fertile ground for exploration and comparison.

---

[17] https://www.metmuseum.org/art/collection/search/640046
[18] https://www.britishmuseum.org/collection/object/W_1991-0408-0-1

Figure.18: Zenderoudi. C. H., (1970s), Calligraphic Painting, oil on canvas,
Reference: Private collection.

In the course of my artistic endeavors, I have created a substantial body of work influenced by the Calligraphic Painting style. However, my artistic practices have been characterized by a quest to establish my unique artistic identity within this tradition. To this end, I embarked on an exploration of materials and techniques, notably adopting the Persian reed pen in a novel manner, akin to a brush.

The decision to employ the Persian reed pen as a brush was driven by an appreciation for the tactile and visual qualities it imparts to the canvas or paper surface. This unconventional approach allowed me to intimately engage with the texture created by the reed pen, which, when utilized as a brush, produces distinctive and captivating marks.

In stark contrast to the conventional use of calligraphy to convey textual content, my creative process revolved around delving into the intrinsic essence of the calligraphic pen itself. I endeavored to strike a delicate balance between the thickness and thinness of each reed pen, akin to tracing the roots of the brushwork. This meticulous exploration of the reed pen became the foundation for my compositions. In essence, through the manipulation of the Persian reed pen as a brush, I have sought to create compositions that resonate with a profound sense of continuity and evolution within the rich tradition of Calligraphic Painting. (Figure. 19)

Figure. 19: Farahani. M. (2015). Illustration for a solo violin performance using the Persian calligraphy pen .

3.5.1 Abstract Forms in “Calligraphic Painting”

"Calligraphic Painting" in Iran is distinguished by its prominent emphasis on abstract forms and the intricate interplay of visual elements. Many contemporary artists within this tradition skillfully manipulate the contours and rhythms of letters and words, ingeniously crafting compositions that possess both harmony and visual allure, akin to the entrancing cadences of music. The utilization of a diverse palette of intricate textures and unconventional surfaces serves to accentuate the inherent abstract nature of this artistic form. In many instances, the art transcends the semantic significance of words, focusing primarily on their aesthetic and compositional attributes, thereby unfurling a realm of pure abstraction. (Figure. 20)
"Calligraphic Painting", despite its geographical origins, shares certain resonances with Western abstract art, particularly the abstract expressionist movement. Both artistic idioms are united in their prioritization of the visual and emotional resonance within their compositions, effectively transcending literal representation in favor of subjective interpretation.

Figure. 20: Ehsaei. M., (2013), Calligraphic Painting, oil on canvas,
Reference: Private collection.

Nevertheless, discernible disparities surface in the realms of cultural context and technique. Western abstract expressionists such as Jackson Pollock and Willem de Kooning frequently employed spontaneous and gestural brushwork as a means of channeling emotional expression, an aspect central to their creative process. Conversely, Calligraphic Painting remains deeply rooted in the time-honored tradition of Persian calligraphy, marked by meticulous and deliberate strokes and the incorporation of intricate, controlled patterns. While both genres share an exploration of balance and equilibrium in their compositions, they each wield distinct visual languages that reverberate with their respective cultural underpinnings.

It is crucial to note that within the expansive realm of "Calligraphic Painting", one encounters myriad styles, and while pure abstraction is a notable subset, it is but one facet of this multifaceted art form.

3.6 Bridging Tradition and Technology: The Interplay of Abstract Forms in Iranian Calligraphic Painting and Generative Art

The integration of cultural aesthetics, such as the intricate styles found in Iranian Calligraphic Painting, into the domains of generative art and generative music visualization holds profound artistic significance. It not only infuses the art world with a Mosaic of cultural diversity but also serves as a catalyst for pushing the frontiers of artistic expression and technological innovation. As Pablo Picasso said, 'Every act of creation is, first of all, an act of destruction.' This statement by Picasso underscores how innovation and creativity often require breaking away from established norms and embracing new influences, like cultural aesthetics. In this context, the integration of Iranian Calligraphic Painting styles into generative art represents a departure from conventional artistic boundaries, opening up new possibilities for fresh and innovative artistic expression.

The realms of music visualization and generative algorithmic art have witnessed a profound transformation in recent years. However, the integration of cultural aesthetics into these art forms has emerged as a crucial and compelling aspect of this evolution.

Herbert Schiller's theory of cultural imperialism (1976) is foundational to understanding the importance of cultural aesthetics in contemporary art forms. Schiller argued that nations, particularly the United States, could exert influence on a global scale not through traditional territorial colonies but through systems of mass communication. This notion is particularly relevant in the context of algorithmic art, where technology serves as a medium to convey artistic expressions worldwide. (Schille, 2019)

In the world of music visualization, cultural aesthetics play a pivotal role in conveying the essence of a culture's music. By incorporating elements of different cultures, artists can bridge geographical boundaries and promote a cross-cultural exchange of ideas and emotions. The use of diverse cultural aesthetics enriches the visual experience and fosters a deeper connection between the audience and the art.

Marshall McLuhan's concept of the global village (1967) emphasizes the rapid integration of the world through media. In the context of music visualization and generative algorithmic art, this integration translates into a shared artistic experience that transcends geographical constraints (McLuhan 1967:63). Furthermore, McLuhan's idea that we are now living in a synchronous global village suggests that the world is more interconnected than ever before. As a result, the need to embrace cultural aesthetics becomes imperative in creating art that resonates with a global audience. In music visualization and generative algorithmic art, the incorporation of cultural aesthetics provides a platform for artists to express their unique cultural identities. Based on this, in this investigation, I have sought inspiration from Iranian cultural aesthetics to craft immersive and inclusive art forms. Through this approach, we can bridge the gap between different cultures and foster a global artistic community that thrives on the richness of cultural aesthetics.

3.7 Persian music visualization

Persian music visualization remains a niche and relatively unexplored field within the broader context of new media art. Despite extensive efforts, including library searches across various university libraries, academic databases focusing on music and visual arts, conversations with academic musicologists and ethnomusicologists, and engagement with social media communities, no significant attempts, artworks, or studies directly related to Persian music visualization have come to light. This dearth of information may be attributed, in part, to the limited emphasis on new media, interactive art, and music technology within Iranian university curricula. As a result, this project adopted a personalized approach, drawing upon my expertise in both music and visual art to investigate and examine techniques in the computational domain. It aimed to extend the horizons of interdisciplinary exploration within the field of Persian music visualization.

Summary of part 3

In part 3, the intricate relationship between Persian music and Persian calligraphy was explored, highlighting their shared cultural and historical roots. The section delved into the nuances of Persian music, emphasizing its diverse nature and deep connections to Persian literature. It also examined Persian calligraphy as a distinct art form within the broader context of Islamic calligraphy, emphasizing the ontological differences that set it apart. The emergence of "Calligraphic Painting" in Iran as a bridge between tradition
and modernity was discussed and the interplay of abstract forms in Iranian Calligraphic Painting with generative art was examined. Overall, Part 3 underscored the profound cultural significance of these art forms and their potential to inspire innovation and cross-cultural dialogue in contemporary art.

Part 4: Iterative Prototyping

4.1: Building the models to visualize Persian music in real-time

Building a system to visualize music in real-time involves intricate intersections of computational audio analysis and graphics rendering, requiring a depth of understanding in both digital signal processing and computer graphics domains. Historically, such endeavors have been characterized by efforts to transform various musical properties, like pitch or rhythm, into corresponding visual manifestations, such as shapes, colors, or motions (Levin, 2000). As technology progresses, these visualizations have evolved beyond mere oscilloscopes and frequency plots to intricate patterns and animations synchronized with live music input, influenced by various factors ranging from the timbre of instruments to the mood of the melody. Given the complexities of capturing and interpreting musical nuances in real-time, optimizing these systems for performance, accuracy, and visual appeal is an ongoing research challenge. Building upon foundational theories in psychoacoustics and visual cognition, real-time music visualization remains at the forefront of interdisciplinary research bridging art, music, and technology.

It's essential to recognize that there are two predominant approaches in real-time visualization: Firstly, there's the real-time generative music and visuals. This method encompasses the simultaneous algorithmic creation of both audio and visual elements. Rather than just visualizing pre-existing music, this approach dynamically generates the music, typically steered by algorithms, artificial intelligence, or predefined rule sets in a live performance. (See: Alva Noto & Ryuichi Sakamoto: Link, access: Oct 2022)

Concurrently, the visuals are crafted, often being shaped by the generated music or other external inputs. This strategy focuses on instantaneously capturing audio data from varied sources, including live microphones, musical instruments, or other auditory devices. However, due to previously discussed challenges, I opted out of the Real-time audio Input.

Secondly, we have a method that specifically zeroes in on the transformation of musical or sound data into corresponding visual outputs, such as graphics, images, or animations, all in sync with

the pre-recorded music. Think of it as the vivid visualizations you witness in music player software that dynamically shifts and dances in tandem with the music's rhythm and tempo. This visualization is conducted live, ensuring it evolves in real-time with the music, devoid of any noticeable lag. (See: MilkDrop Official website: Link and playing Big Wild: Link, access: Oct 2022)

To develop a real-time visualization system for Persian music that encapsulates its cultural aesthetics, I strategized to incorporate visual motifs intrinsic to Persian art, history, and architecture. I sourced inspiration from age-old Persian calligraphy, traditional paintings, and established compositions, all of which would dynamically evolve in harmony with the musical cues.

4.2 Music input and Visual output

Input: The visual output is generated based on a pre-recorded music input. This pre-recorded track serves as the foundation upon which the visual output is built and also encompasses certain musical elements, including its rhythm, tempo, pitch, and amplitude, among others.

The code analyzes the musical elements of the pre-recorded track. Based on this analysis, the system generates visual elements such as graphics, images, or animations. The visualization is in sync with the music, meaning that changes in the music (like a beat drop or crescendo) result in corresponding changes in the visual display. This ensures that the viewer experiences the visuals as a direct representation or interpretation of the music.

Output: Incorporating visual motifs inspired by Persian calligraphy letters, I aimed to create some artworks from scratch with a hybrid approach. This process began with calligraphy of letters in the Nastaliq style, using a traditional reed pen (Figure. 21). Subsequently, I scanned the letters and imported these letters into the programming environment, where I initiated the coding and image manipulation phases.

As a result, the visualization responds to the music, adhering to a predefined aesthetic framework influenced by Persian cultural elements. For example, a short and intense beat within the music

might trigger the expansion or transformation of a Persian calligraphy motif into intricate patterns.

In essence, this approach establishes music as the driving force behind the visuals. I lacked the time to visit a music recording studio for the purpose of recording my music while simultaneously playing and singing. The pre-recorded music tracks serve as the primary data source that fuels the visualization system, enabling the generation of real-time visuals that harmonize seamlessly with the music.

However, I am committed to recording my own music in the future and independently creating the accompanying visuals.

Figure. 21: Farahani. M (2022), Calligraphy of letters in the Nastaliq style, using a traditional reed pen

4.3 Exploring the Potential of Teachable Machine in Music

The initial objective of my project was to impart the sound of various Persian musical instruments to an AI system, enabling it to discern distinct tonal characteristics through audio input. Aspired to undertake a comprehensive project encompassing music composition, design, calligraphy, and programming, I embarked on the task of training the model with my own instrument and vocal capabilities. Consequently, the machine training process commenced. Initially, I was not sure about the machine's ability to accurately differentiate between tonal nuances using its provided model. To address this, I classified the training data into three distinct categories. The first class consisted of background noise, for which I gathered 50 samples. The second class was dedicated to the Setar, a three-stringed Iranian instrument. To facilitate its recognition, I performed for a total of 200 samples across three octaves, employing diverse techniques and notes.

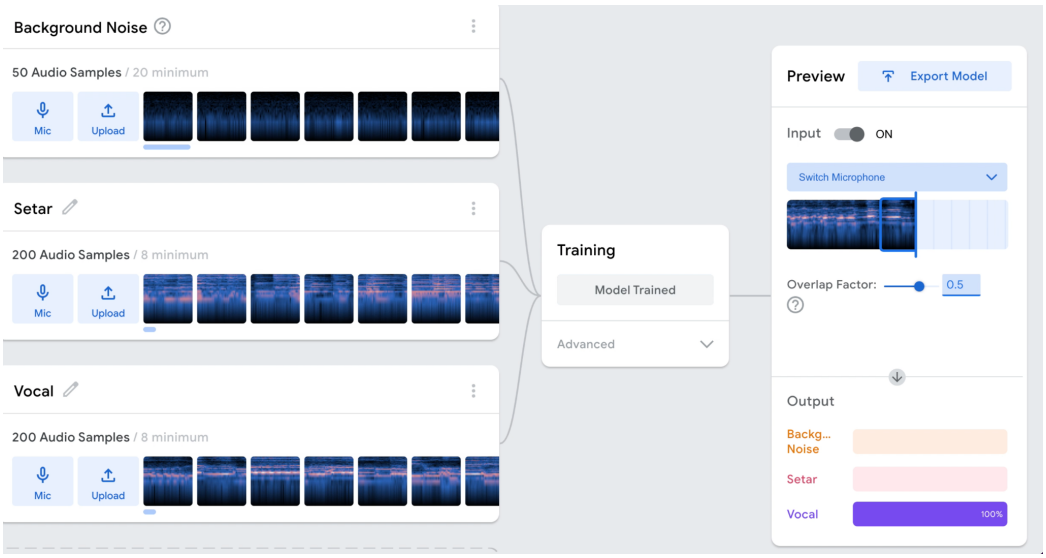


Figure. 22: Training an audio model by Setar and Vocal (200 Audio Sample)

For the third class, I recorded an additional 200 samples of my own vocal. Within the same tonal framework, I incorporated three chords and proceeded to sing, endeavoring to impart the full range of my vocal qualities spanning up to two and a half octaves, along with the accompanying

poem. Following the completion of the training process, I received the output and conducted tests by playing musical samples and singing, which yielded satisfactory results. (Figure. 22) This encouraged me to believe that by incorporating a greater number of training samples, the accuracy of the AI system's recognition would undoubtedly improve.

4.3.1 Exploring the Potential of Musical Note Detection

In the second phase of experimentation, my objective was to expand the available audio frequencies by training the machine on musical notes. This would enable the generation of distinct representations for each individual note. Despite creating 100 samples for each musical note by Setar, the machine's accuracy did not meet the desired level of precision. Upon completion of the learning process and analyzing the output, I observed that the machine incorrectly identified certain notes, thus recognizing a percentage of other notes as well. In an attempt to enhance accuracy, I conducted multiple tests with 200 samples. However, due to the limitations of the machine's development regarding fine-grained accuracy, precise detection of audio frequencies proved to be unattainable. Consequently, it became evident that a portion of my original idea was not feasible using this method. (Figure. 23)

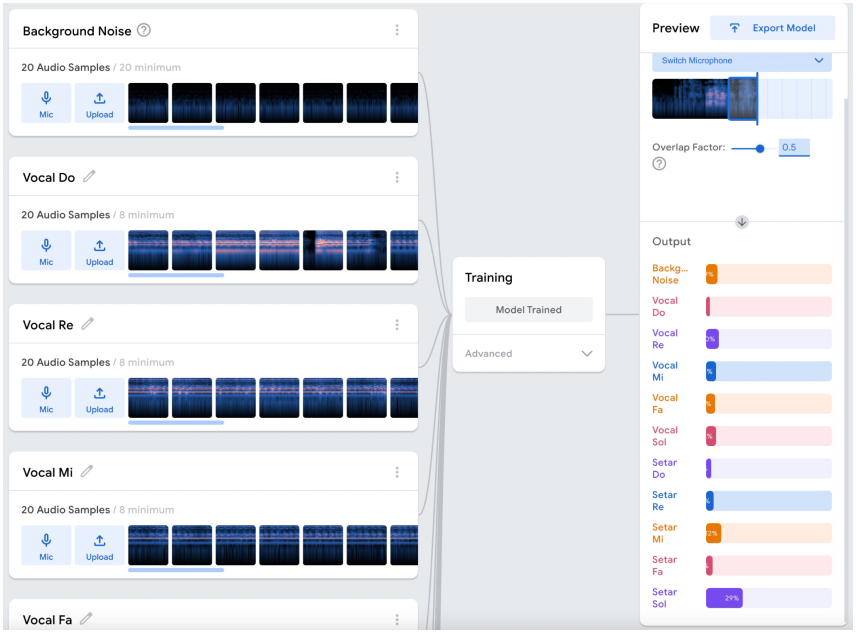


Figure. 23: Training an audio model by Musical note (Setar & Vocal)

4.3.2 Reflection

In my initial idea, I aimed to train the machine on Persian musical instruments to achieve sound classification; an act not yet attempted in the realm of Persian music. This pioneering nature of my idea meant I couldn't leverage existing findings or build upon pre-existing models within a constrained time frame. While I considered adapting research from Western music, the time constraints rendered this approach challenging. This propelled me to delve into more straightforward and varied machine-learning techniques.

The ultimate goal of this sound classification was to facilitate a live concert where a single microphone could capture and distinctly identify multiple sounds in real time, serving as the basis for my input.

The techniques such as deep learning and neural networks, are more advanced and flexible approaches to training machine learning models, including audio models. These techniques involve designing and implementing custom architectures, selecting appropriate algorithms, and training the models using large datasets.

On the other hand, Teachable Machine is a simplified tool that abstracts away much of the complexity of building and training machine learning models. It provides a user-friendly interface and pre-built neural network models, making it accessible to individuals without extensive coding or machine learning expertise. Teachable Machine primarily uses transfer learning, which leverages pre-trained models and allows users to fine-tune them for their specific tasks using their own labeled data.

Here are some key differences I found between Teachable Machine and the advanced techniques:

Ease of Use: Teachable Machine is designed to be beginner-friendly and requires minimal coding or technical knowledge. It provides a visual interface and simplifies the process of training models. Advanced techniques, on the other hand, require more expertise in machine learning and programming.

Flexibility and Customization: Advanced techniques offer greater flexibility in designing custom architectures, selecting specific algorithms, and fine-tuning models according to specific

requirements. Teachable Machine, while versatile, has certain limitations in terms of model complexity and customization.

Computational Resources: Advanced techniques often require significant computational resources, including powerful hardware (e.g., GPUs) and time for training complex models. Teachable Machine, being a web-based tool, handles the training process on remote servers, reducing the computational requirements on the user's end.

Scope and Complexity: Advanced techniques can handle a wide range of complex tasks and accommodate larger datasets. Teachable Machine, while capable of training audio models, may have limitations in terms of the complexity and scale of the tasks it can handle.

In summary, Teachable Machine offers a streamlined and user-friendly methodology for the training of machine learning models, including those specific to audio. It makes the intricate world of machine learning more approachable to those who might not possess in-depth technical or coding expertise. While advanced methods provide greater room for customization, adaptability, and scalability, they also demand a comprehensive grasp of machine-learning intricacies and programming acumen.

After dedicating a significant amount of time to training a sound classifier that aimed to discern the quality and modal variances within sounds, I integrated this machine-learning model into a p5.js sketch using the ml5.js library. However, I found that the accuracy level of this approach didn't align with my initial objectives. Even though tackling more advanced techniques could yield better results, it's also time-consuming. Based on recommendations from my adviser, I've opted to defer this specific segment of my research to a later date, ensuring that it can be tackled with more precision and clarity when revisited.

4.4 P5.js

P5.js is a widely recognized JavaScript library tailored for artists, designers, educators, and beginners to create interactive visual experiences on the web. A new domain where p5.js has shown immense utility is in the realm of music visualization.

When visualizing music with p5.js, several data types can be obtained from digital audio tracks, ranging from frequency amplitude to waveform shape. This data extraction allows artists and coders to craft intricate visual narratives synced with the music's tempo, rhythm, and tonal changes. p5.js, when combined with its sound library (p5.sound)[19] , provides a rich set of functionalities for audio input, playback, analysis, and synthesis. Here are some basic audio and sound analysis capabilities for music visualization in p5.js that I have used:

Frequency Analysis [20]

By leveraging FFT, it's possible to dissect an audio signal into its component frequencies, allowing for the visualization of amplitude across different frequency bands.
(see. Model. 1)

Amplitude Analysis [21]

This involves determining the volume or loudness of an audio signal over time. With p5.Amplitude, users can analyze and retrieve the amplitude of a sound source, whether it be a preloaded sound file, streamed music, or even real-time microphone input. The resulting amplitude values range between zero and one, with zero indicating silence and one representing the maximum amplitude. (see. Model. 2)

[19] https://p5js.org/reference/#/libraries/p5.sound
[20] https://p5js.org/reference/#/p5.FFT
[21] https://p5js.org/examples/sound-measuring-amplitude.html

4.4.1 Reflection

P5.js is a powerful JavaScript library designed for creative coding, with a particular emphasis on visual arts and interactive designs. However, when it comes to music visualization, it might have certain limitations compared to other specialized techniques and software. I try to list some challenges that I faced:

1- Persian language and Persian fonts:
Working with non-English languages and fonts can indeed be challenging in certain programming environments, including P5.js. While experimenting within this environment, I explored using speech recognition for real-time input. However, despite P5.JS performing admirably in detecting English words, it struggled with recognizing the Persian language. This issue persists across various programming software and environments, often requiring the creation of a model from scratch and extensive training.
Furthermore, the Persian font doesn't seamlessly integrate into P5.JS; its tendency to separate letters creates a hurdle since Persian letters are typically joined together, unlike English letters.

2- Performance:
Being a JavaScript-based library, p5.js runs in the browser, which may be slower than native or dedicated applications for music visualization. This could impact the real-time rendering of complex visualizations.

3- Limited Built-in Audio Analysis:
While p5.js does provide some audio analysis tools, other specialized software or platforms such as (Sonic Visualiser, SpectraLayers, Ableton Live, Steinberg WaveLab Elements, MATLAB and Python, might offer more advanced audio processing and analysis capabilities.

4- Lack of Advanced Features:

Specialized software for music visualization might come with a suite of advanced features, effects, and presets that are not natively available in p5.js. To achieve similar effects in p5.js, one might have to code them from scratch. For Example a Timbre detection. Timbre defines the unique quality or color of a sound, allowing for differentiation between tone quality of instruments. By detecting the timbre, visualizers can assign different colors or visual elements to various instruments, enhancing the richness of visual feedback. In p5.js, there isn't a single function specifically labeled for timbre detection, and we can analyze various aspects of a sound that contribute to its timbre like FFT and Amplitude Analysis.

5- Integration with Professional Audio Systems:

P5.js may not integrate as seamlessly with professional audio systems or Digital Audio Workstations (DAWs) as some dedicated music visualization software.

6- Synchronization:

I've experienced a problem with p5.js when integrating music and visuals, especially when sharing sketches in fullscreen mode. It's frustrating when the tempo of the music doesn't align with the visuals, especially when everything works perfectly within the Editor area. One contributing factor might be how web browsers handle media playback. Some browsers, like Chrome,[22] have implemented autoplay policies that prevent audio from playing automatically until there's some form of user interaction with the page. This could potentially introduce a lag or delay, disrupting the synchronization between the audio and visuals as they transition into fullscreen mode. I've tested this on multiple browsers, only to find inconsistent results. Another apparent explanation is the implementation of the fullscreen functionality within p5.js itself. The fullscreen() function[23] in p5.js either activates the fullscreen mode based on the provided argument or returns the current state of the screen. However, even with an understanding of how this function operates, the synchronization issue persists in fullscreen mode.

[22] https://github.com/processing/p5.js-web-editor/issues/798
[23] https://p5js.org/reference/#/p5/fullscreen

4.4.2 Model 1

In the initial prototype visualization, my aim was to faithfully replicate the distinctive diagonal form of “Siāh Mashq”. In the realm of generative art, this model amalgamates the principles of traditional Persian aesthetics with modern computational design. It displays a musical visualizer grounded in the nuances of "Siyāh Mashq". The diagonal compositions are symbolic of the Persian “Siyāh Mashq” aesthetics, providing a synergistic blend of cultural heritage and technology. (see. Figure. 16)

Figure. 24: Farahani. Mehdi (2022), A computational sketch based on diagonal compositions of Siyāh Mashq, Github repository: P5-music-visualizer-3, Link

In this project (Figure. 24), I integrated the visuals with real-time audio analysis using p5.js. Within the preload function, essential assets like images, and a piece of Persian music track are loaded, ensuring uninterrupted real-time operations. The setup orients the canvas to be

responsive to window dimensions and utilizes (FFT) for audio frequency analysis. In the primary draw loop, the canvas is continually refreshed and audio frequencies are analyzed, resulting in a waveform that dictates the emulative traditional Persian patterns. I introduced a Particle class where each particle, bearing a random image and a rotational alignment reminiscent of the diagonal composition of Persian “Siyāh Mashq” aesthetics, responds dynamically to the music's amplitude. Furthermore, user interactivity is achieved via the mouse-clicked function, allowing a seamless toggle between music play and pause, fostering a symbiotic relationship between sight and sound. In this endeavor, I ventured beyond conventional generative patterns, instilling the essence of Persian musical and visual aesthetics into a computational design. By harnessing the power of p5.js, the visualizer not only echoes the rhythmic undulations of the accompanying music but also paints a canvas resonant with Persian cultural imprints.

4.4.3 Model 2

The technique used in the second sketch is primarily based on analyzing the audio waveform's amplitude to create a music visualization. Specifically, it uses the amplitude of the audio waveform to control various visual aspects, such as particle movement, size, and color. Amplitude represents the intensity or loudness of the audio signal at a given point in time. In this experiment, the amplitude values from the waveform are mapped to particle properties to synchronize the visual effects with the music. While the FFT technique in the previous sketch is for audio analysis in music visualization, this experiment focuses on amplitude-based visualization, where the amplitude values are directly used to modulate the visual elements.
The visual part adopts a contemporary style that diverges from the strict conventions of "Siah Mashq." Instead of meticulously adhering to traditional forms, the visuals embrace a more modern and dynamic approach. The particles move together, almost as if they are dancing in response to the music. The code orchestrates their movement and appearance based on the audio waveform, infusing a sense of spontaneity. This results in a captivating and immersive experience where the letters appear to come together, not in a rigid manner, but with a fluidity that mirrors the rhythm and energy of the music. (Figure. 25)

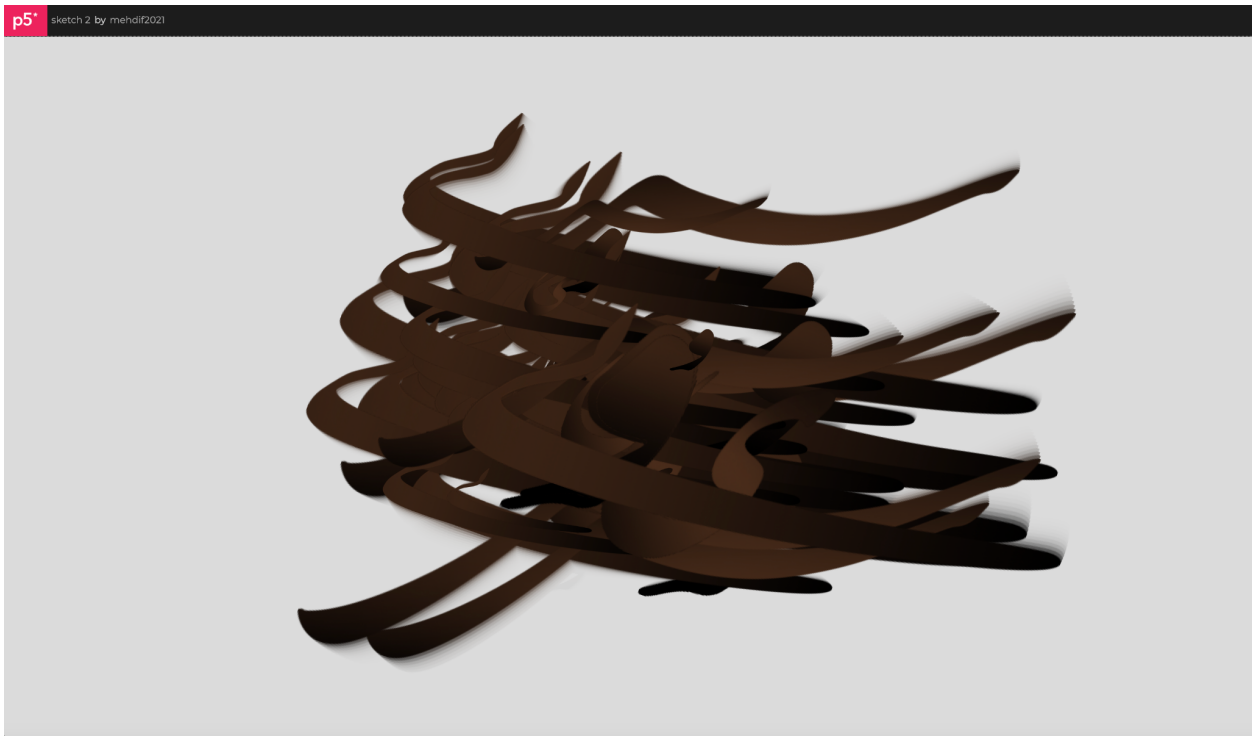


Figure. 25: Farahani. Mehdi (2022), A computational sketch based on "Siyāh Mashq" style.

4.4.4 Model 3

For the third prototype visualization, I set out to freely explore the form of Persian "Calligraphic Painting" style. I aimed to create a dynamic and visually engaging composition that synchronizes with the music, using a circular motif inspired by modern Persian calligraphy and symbolic representations of time, infinity, and the spiritual world.

I explored the concept of a circular composition, where the circle symbolizes time, a series of moments repeated without change, and the concept of infinity. Additionally, the circle represents the continuous, circular movement of the sky, associated with divinity and the transcendent world. The circular composition of the visuals is achieved through the arrangement of particles that move around a central "dot" and vary in size and color, creating a dynamic and captivating generative scene.

To synchronize the visuals with the music, I utilized the p5.js library's both FFT and Amplitude functions to analyze the audio frequencies and amplitude of the music in real time. The

amplitude of the music is used to scale the size of the central "dot" image (centering). As the music's amplitude changes, the size of the central image dynamically adjusts, creating a visual representation of the music's intensity.

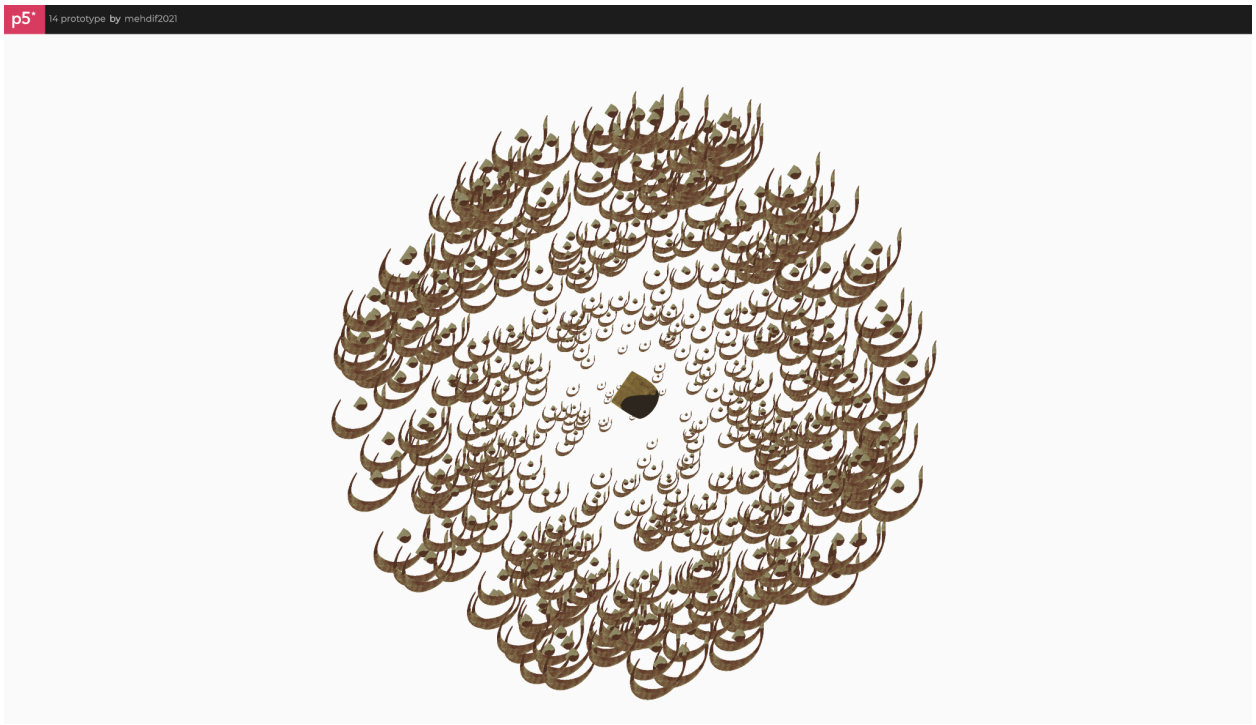


Figure. 26: Farahani. Mehdi (2022), A computational sketch based on contemporary composition of "Calligraphic Painting" style.

The FFT function is used to extract audio frequency data, and the waveform is used to generate a waveform visualization. These elements are incorporated into the circular composition, with the waveform points forming the outer boundary of the circle. The amplitude of the music influences the radius of the circle, further enhancing the synchronization between visuals and audio.
The movement of particles within the circular composition is influenced by the audio amplitude and randomly generated patterns. The particles move in a circular motion, reflecting the concept of continuity and circularity. Their size and color are influenced by depth and amplitude, creating a sense of depth and dimension within the composition.

I provided interactivity through a mouse click event, allowing users to play and pause the music, which in turn affects the animation of the visuals. This interaction enhances the overall user experience and engagement with the music visualization.
Ultimately, this music visualization experiment aims to create a harmonious and immersive experience by combining elements of Persian calligraphy symbolism, circular composition, real-time audio analysis, and interactivity. The synchronized visuals and music offer a dynamic representation of the music's mood and intensity, inviting viewers to explore the connection between sound and visual art. (Figure. 26)

4.4.5 Model 4

In this experiment, unlike the previous attempts, I aimed to create a dynamic and ever-changing visual experience that responds to the music's volume levels, with a focus on abstract Persian calligraphy-inspired compositions.
I sought to create a visually dynamic and generative art piece that continuously evolves and offers a unique experience each time it is played. To achieve this, I implemented various movement patterns for particles, resulting in ever-changing compositions. The visuals are not static or predictable, providing viewers with a fresh and engaging experience with every Play/Pause functionality.
I incorporated an interaction by changing the color of the particles' images based on the music's volume level. When the volume increases, the particles' images turn black, and when the volume decreases, they turn white. This interaction creates a direct link between the music's intensity and the visual composition, making the experience more immersive and responsive.
To ensure visual diversity and maintain viewer engagement, I implemented different movement patterns for particles. These patterns include circular motion, random noise-based movement, and a combination of rotation and translation. Each movement pattern contributes to the overall visual experience, creating a sense of dynamism and unpredictability.

The experiment includes an interactive play/pause functionality triggered by a mouse click event. This feature allows users to control the music and visuals, providing an additional layer of engagement and agency in shaping their experience.

The visuals are synchronized with the music through real-time audio analysis using the p5.js library's FFT. The volume level influences the color of particles, creating a direct connection between the auditory and visual elements. This synchronization adds depth and meaning to the visual experience, as viewers can perceive changes in the music through alterations in the visuals.

In closing, this music visualization experiment is a fusion of generative art, dynamic visuals, abstract Persian calligraphy-inspired compositions, and interactive elements. By changing the color of particles based on music volume and implementing diverse movement patterns, I aimed to create a visually captivating and ever-evolving experience that reflects the spirit of abstract art and the beauty of Persian calligraphy's aesthetics. (Figure. 27)

Figure. 27: Farahani. Mehdi (2022), A computational sketch based on "Calligraphic Painting" style, Github repository: P5-music-visualizer-2, Link

4.4.6 Model 5

I aimed to enhance the visual appeal of my music visualization project by incorporating vibrant Iranian colors, notably the vivid Iranian red and the harmonious green-blue shades frequently found in Iranian architectural designs and paintings. These colors were chosen to infuse a sense of dynamism and spirit into Persian visual aesthetics, ensuring that they evolve continuously through various combinations while remaining artistically engaging and aesthetically stimulating. My intention was to create a dynamic interplay of colors that would produce diverse visual effects each time the program ran.

To achieve this, I drew inspiration from Iranian calligraphy and the repetitive black patterns prevalent in Iranian Siah Mashq. Within this amalgamation, I integrated the letter 'ن', which I had previously scripted using a traditional reed pen. These letterforms were positioned to overlap and move in unison, with meticulous attention paid to controlling the rhythm and tempo at which they transformed and transitioned.

In terms of coding methodology, I strived to maintain a degree of separation between the visual elements and the accompanying music, allowing the images to evolve randomly without direct interference. Consequently, anyone utilizing this model as a plugin in their application and repeatedly playing the associated music would witness a wide array of unique visual combinations on each iteration.

Nevertheless, there was a specific instance in which I endeavored to convey a specific meaning through the visuals. Those well-versed in mystical traditions and rituals in Iran may be aware of a longstanding mystical ritual and "Sama" involving music and dance. This mystical ritual has persisted throughout history, particularly in western regions of Iran. During these ceremonies, participants form circular patterns, engaging in synchronized spinning and dance movements. The ritual is accompanied by music and rhythmic beats, occasionally featuring a solo dancer at the center of the circle, with others moving in harmonious synchrony around them. Similar forms of dance can also be observed in contemporary contexts in India and Turkey.

Drawing inspiration from these ancient mystical dances and infusing them with elements of Iranian calligraphy, I sought to visually capture the essence of this ceremonial atmosphere.

Through my music visualization, I aimed to evoke the spiritual and rhythmic harmony inherent in these traditional practices, bridging the gap between the past and the present while paying homage to the rich cultural heritage of Iran.

In this project, I have created a music visualization that harmonizes audio and visuals to craft an immersive experience. Leveraging previous experiments, I have harnessed the power of FFT (Fast Fourier Transform) to analyze the audio spectrum of the music, allowing me to translate it into dynamic visual elements.

```
23  fft = new p5.FFT();
24  song.onended(songEnded);
25
26  movementPatterns.push({
27    update: function(particle) {
28      particle.target = createVector(random(-width / 2,
width / 2), random(-height / 2, height / 2));
29      particle.update();
30    }
31  });
32
33  movementPatterns.push({
34    update: function(particle) {
35      var angle = map(particle.index, 0, particles.length,
0, 360);
36      var radius = width / 2;
37      var x = radius * cos(angle);
38      var y = radius * sin(angle);
39      particle.target = createVector(x, y);
40      particle.update();
41    }
42  });
43
44  movementPatterns.push({
45    update: function(particle) {
46      var angle = map(particle.index, 0, particles.length,
0, 360);
```

Console

Figure. 28: Farahani. Mehdi (2022), A computational sketch based on the fusion of calligraphy compositions,Github repository: P5-music-visualizer-1, Link

The core of this visualization lies in a collection of particles, each with its unique behavior and motion patterns. These particles react to the music's nuances, creating a dynamic and ever-changing visual landscape. I have implemented movement patterns that range from random motion to more structured circular orbits, lending diversity and intrigue to the visual compositions.

To further enrich the aesthetics, I have introduced a sophisticated color scheme that adapts to the music's volume. As the music's intensity fluctuates, the particles' colors shift accordingly, providing an emotional resonance between the auditory and visual elements.

One of the distinctive features of this project is the gradual movement of particles towards the center, which occurs during a specific phase of the music. This progression introduces a sense of unity and oneness to the visualization, making it feel like an evolving story.

The inclusion of a rotating "ن" image, tinted to sync the music's tempo, adds an extra layer of uniqueness to the experience. This visual element not only enriches the overall aesthetics but also serves as a focal point, enhancing the immersion.

This project is not merely a passive music visualization; it's an interactive journey. Users can effortlessly control the music playback by clicking, providing an avenue for personal engagement and exploration. (Figure. 28, 29, 30, 31)

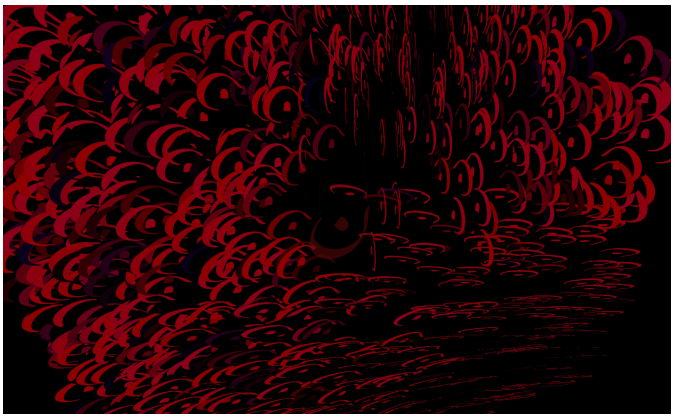


Figure. 29: Farahani. Mehdi (2022), A computational sketch based on the fusion of calligraphy compositions, Github repository: P5-music-visualizer-1, Link

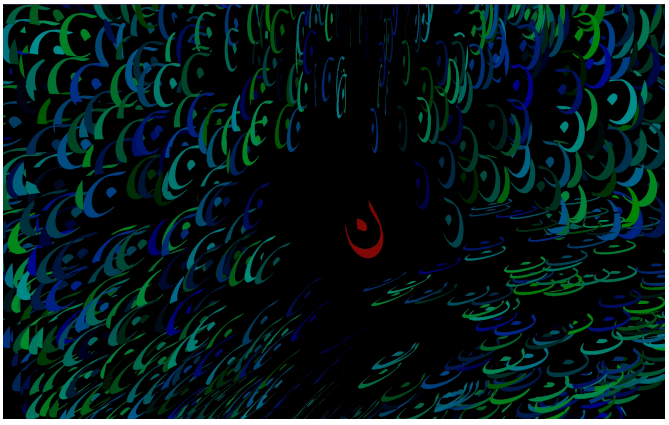


Figure. 30: Farahani. Mehdi (2022), A computational sketch based on the fusion of calligraphy compositions, Github repository: P5-music-visualizer-1, Link

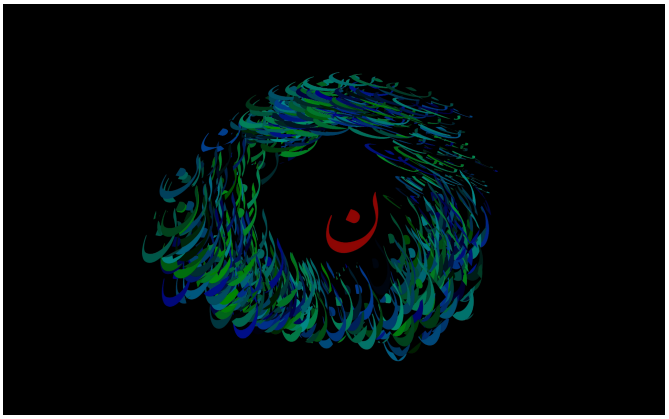


Figure. 31: Farahani. Mehdi (2022), A computational sketch based on the fusion of calligraphy compositions, Github repository: P5-music-visualizer-1, Link

Conclusion

In conclusion, this thesis has delved into the intricate realm of Persian visual arts and Persian traditional music, seeking to harmonize their aesthetic features through computational methodologies. I have argued that the fusion of these two distinct art forms offers a unique opportunity for creative exploration and expression.

As a researcher and artist, my intellectual journey commenced with a strict and critical approach. It became evident that existing literature and scholarly works within the realm of academia fail to provide a holistic and methodical explanation of the “music visualization” phenomenon. It's difficult to pinpoint the exact origin of the term "music visualization", but we can trace its development to various scholars and artists who contributed to its conceptualization and evolution.

Through a comprehensive literature review in Part 1, I have argued that music visualization is a multifaceted field with a rich historical evolution, diverse methodologies, and emerging contemporary practices. The delineation between sound and music visualization, coupled with a historical examination of visualizing sounds, laid the groundwork for understanding the field's evolution and the impact of technological advancements. Within this context, I have argued that music visualization is a dynamic and evolving discipline, shaped by technological innovations and artistic creativity. The exploration of traditional and contemporary approaches has revealed the vast potential for visual elements to enhance and transform our musical experiences. This understanding paved the way for a structured framework for categorizing music visualization experiences, which addresses the fundamental question of how computational methodologies can facilitate the harmonization of aesthetic features in Persian visual arts with those of Persian traditional music.

In Part 2, I continued to address the research questions by delving into the intricacies of the relationship between sound and image, and investigating how artists can evoke synesthetic experiences in their audiences. I argued that the harmonious interplay between sound and sight enriches artistic expression and reshapes perspectives, pushing the boundaries of sensory experience and creative expression.

Part 3 shifted the focus towards Persian art and its cultural significance. I argued that a deep understanding of Persian art, including Persian music and calligraphy, is essential to achieve the harmonization of aesthetics. The examination of Persian music and calligraphy's symbiotic relationship highlighted the cultural and historical roots that underpin these art forms. This section provided valuable insights into the distinctive visual elements of Iranian art, setting the stage for their integration into music visualization.

Finally, in Part 4, I addressed the practical aspect of my research by developing an iterative prototype that sought to implement the theoretical concepts discussed throughout the thesis. Through the exploration of machine learning and real-time visualization, I attempted to bridge the gap between Persian music and Persian calligraphy, aiming to create a model that could capture the emotional essence of the music in visual form.

It was hypothesized that tailored computational methods, recognizing and representing the nuanced aesthetic qualities of Iranian visual arts and traditional music, could unveil a myriad of visual possibilities.

The thesis unearthed more questions than it answered practically, fostering an understanding that the exploration of the harmonization of these aesthetic features is an ongoing and evolving pursuit. The primary question—how computational methodologies can facilitate the harmonization of Persian visual arts with traditional music—provides a fertile ground for future research and creative endeavors.

The constraints of time, particularly the lengthy machine training period spanning over a year, led me to reevaluate my approach during the course of this experiment. Consequently, I decided to pivot away from the machine learning aspect and explore an alternative approach. Throughout this journey, I meticulously crafted numerous models, each representing a unique approach to the project. Among the multitude of models, I selected five that best encapsulated the initial direction from which I embarked on this project. These chosen models serve as a testament to the iterative and adaptive nature of my creative process, showcasing the evolution and refinement of my ideas as I navigated the challenges and constraints of the project.

This journey has been a profound learning experience for me, where I explored various techniques and approaches, each of which was constrained by my technical limitations and my

familiarity with different programming languages. Despite facing these constraints, I embarked on my first venture into this realm, and while I may not have fully reached the exact visions that initially inspired me, the questions I posed at the outset of this study continue to occupy my thoughts.

As a musician and painter, I have always thought about the dialogue between image and sound. Prior to this study, I had never imagined that I could be someone who would engage in such scientific endeavors. Over the course of my 20-year artistic journey, I have consistently sought to convey the essence of sound through visual artworks, encouraging my students to visualize musical notes and create a melodic world of images. This study has reinforced my belief in the potential of merging the auditory and visual realms to tell stories and convey emotions.

While my current project may not have realized my artistic aspirations, it has ignited a passion within me to further experiment and explore the uncharted territory where music and visuals intersect. The challenges and limitations I encountered have only fueled my determination to continue this creative journey, with the hope of getting closer to achieving the results I envision. In essence, this study marks the beginning of an ongoing quest to bridge the gap between my artistic vision and the possibilities of technology, and I look forward to the exciting discoveries that lie ahead.

In this study, my purpose behind creating these music visualizer models and the chosen development approach are pivotal in understanding its potential reach and significance. These models possess a remarkable versatility, allowing for their adaptation and customization across many platforms and applications. It can be tailored to serve as a downloadable product on online marketplaces like Gumroad, Etsy, or itch.io, making it accessible to a global audience of Persian music. Additionally, the model's potential extends to integrating app stores such as the Apple App Store or Google Play Store for users seeking standalone applications. Users can easily download these customized visualizations onto their mobile or desktop applications, providing them with a captivating audiovisual accompaniment that enhances their listening experience. By catering to the distinct characteristics and moods of different types of Persian music, this model serves as a valuable tool for both musicians and music enthusiasts seeking to immerse themselves in Persian calligraphy and Persian musical traditions. This adaptability underscores

the dynamic interplay between technology, cultural expression, and audience engagement, fostering a deeper connection between Persian music and its appreciators.

As this study delves into the intricate relationship between Persian music and visualizations, it also paves the way for a multitude of future research avenues and creative endeavors. One promising direction for future research involves the exploration of cross-cultural applications of this music visualization approach. Examining how it can be adapted to other musical traditions and global audiences will shed light on its potential to bridge cultural divides through shared audiovisual experiences.

Investigating the feasibility of employing advanced sound classification techniques to train the Persian music repertoire, specifically the 'Radif,' which stands as one of the world's most ancient musical genres, in conjunction with the imperative task of real-time training for Persian musical instruments, presents an untapped avenue for my forthcoming research endeavors.

These future research directions aim to not only advance our comprehension of the intricate interplay between visual and auditory stimuli but also to open doors to new forms of cultural expression and emotional resonance in the realm of Persian music and beyond.

Furthermore, delving into various elements of Persian visual culture, particularly those that do not stem from calligraphy, endeavoring to establish a meaningful connection between Persian miniature art and Persian music, or uncovering deeper nuances within the realm of Persian arts, will be the next phase of my exploratory journey. Additionally, I intend to conduct experiments with alternative AI techniques and harness emerging technologies such as VR/AR, while also engaging with Generative Adversarial Networks (GANs), as part of my evolving endeavors in this domain.

Bibliography

Primary Sources:

Chladni, E. F. F. (Ernst Florens Friedrich). (1787). Entdeckungen über die Theorie des Klanges. Leipzig: Bey Weidmanns Erben und Reich.

Kandinsky, W. (1911). *On The Spiritual in Art:* 1911 by Piper and Company, Munich

Tyndall, J. (1867). Sound: A Course of Eight Lectures Delivered at the Royal Institution of Great Britain.

Unknown. (1843). Analogy between Color and Sound. Lloyd's Weekly Newspaper. LONDON.

Secondary Sources:

Allen, K. (2016). *A naive realist theory of colour*. Oxford University Press

Bartolome, J. I., Cho, G., & Cho, J.-D. (2021). Multi-Sensory Color Expression with Sound and Temperature in Visual Arts Appreciation for People with Visual Impairment. Electronics, 10(11), 1336. https://doi.org/10.3390/electronics10111336

Bernard, J. W. (1986). Messiaen's Synaesthesia: The Correspondence between Color and Sound Structure in His Music. *Music Perception: An Interdisciplinary Journal*, *4*(1), 41–68. https://doi.org/10.2307/40285351

Bragança, G. F. F., Fonseca, J. G. M., & Caramelli, P. (2015). Synesthesia and music perception. *Dementia & neuropsychologia*, *9*(1), 16–23. https://doi.org/10.1590/S1980-57642015DN91000004

Billings J. S. 1888. The history of medicine. *The Boston Medical and Surgical Journal* 118:57–60. doi: 10.1056/NEJM188801191180301.

Binet A. 1892. Le problème de l'audition colorée [The problem of colored hearing]. *La Revue des deux mondes* 113:586–614.

Bordwell, D. and Thompson, K. (1985). Fundamental aesthetics of sound in the cinema. In Filmsound: Theory and practice (ed. E. Weis and J. Belton), pp. 181-199. Columbia University Press, New York

Bor, D., Billington, J., & Baron-Cohen, S. (2014). Adults can be trained to acquire synesthetic experiences. Scientific Reports, 4, 7089.

Brang, D., & Ramachandran, V. S. (2011). Survival of the synesthesia gene: why do people hear colors and taste words?. *PLoS biology*, *9*(11), e1001205. https://doi.org/10.1371/journal.pbio.1001205

Curwen, C., Timmers, R. & Schiavio, A. Action, emotion, and music-colour synaesthesia: an examination of sensorimotor and emotional responses in synaesthetes and non-synaesthetes. *Psychological Research* (2023). https://doi.org/10.1007/s00426-023-01856-2

Chiou, R., & Rich, A. N. (2014). The role of conceptual knowledge in understanding synaesthesia: Evaluating contemporary findings from a "hub-and-spokes" perspective. *Frontiers in psychology*, *5*, 105. https://doi.org/10.3389/fpsyg.2014.00105

During, J. (1982). Music, Poetry and the Visual Arts in Persia. *The World of Music*, *24*(1), 72–88. http://www.jstor.org/stable/43562655

Ekhtiar, M. (2006). Practice Makes Perfect: The Art of Calligraphy Exercises (Siyāh Mashq) in Iran. *Muqarnas*, *23*, 107–130. http://www.jstor.org/stable/25482439

Flynn, E. N. (2014). Liberation of the Senses: An Exploration of Sound-Color Synesthesia in the Music of Alexander Scriabin and Olivier Messiaen [Thesis, University of Kansas]. Retrieved from https://kuscholarworks.ku.edu/handle/1808/18408

Glasser, S. (2023). The Relationship Between Music-Related Types of Synesthesia and Mental Imagery in Synesthete Musicians. *Music & Science*, *6*. https://doi.org/10.1177/20592043231173810

Hemingway, C., & Hemingway, S. (2000). Music in Ancient Greece. In Heilbrunn Timeline of Art History. New York: The Metropolitan Museum of Art. Retrieved from http://www.metmuseum.org/toah/hd/grmu/hd_grmu.htm (October 2001)

Isaacson, E. (2023). Visualizing Music. United States: Indiana University Press.

Kazemi, B. (2002). National Identity in the Songs of Iranian Ethnic Groups. Institute of National Studies Publication.

Levin, G. (2000). Painterly Interfaces for Audiovisual Performance. *Massachusetts Institute of Technology*.

Lima, H., dos Santos, C. G. R., & Meiguins, B. S. (2021). Survey of Music Visualization Techniques. *ACM Computing Surveys, 54*(7), 1-29. https://doi.org/10.1145/3461835

Lipscomb, S. D., & Kendall, R. A. (1994). Perceptual judgment of the relationship between musical and visual components in film. *Psychomusicology: A Journal of Research in Music Cognition, 13*(1-2), 60–98.

Miller, K. (2012). How Musical Is Guitar Hero? In *Playing Along: Digital Games, YouTube, and Virtual Performance*. Oxford Music/Media Series. Oxford Academic. Retrieved October 16, 2023, from https://doi.org/10.1093/acprof:oso/9780199753451.003.0003

Morris, Richard and Sharman, Hugh R. (2002). "Images of Sound." The University of Toronto.

Sarker IH. Machine Learning: Algorithms, Real-World Applications, and Research Directions. SN Comput Sci. 2021;2(3):160. doi: 10.1007/s42979-021-00592-x. Epub 2021 Mar 22. PMID: 33778771; PMCID: PMC7983091.

Schiller, H. I. (2019). Revival: Communication and Cultural Domination (1976). United Kingdom: Taylor & Francis.

Short, C. (2009). The Art Theory of Wassily Kandinsky, 1909-1928: The Quest for Synthesis. Peter Lang

Stöckmann, H.-J. (2007). Chladni meets Napoleon. The European Physical Journal Special Topics, 145(1), 15–23. doi:10.1140/epjst/e2007-00144-5.

Tiihonen, M., Brattico, E., Maksimainen, J., Wikgren, J., & Saarikallio, S. (2017). Constituents of Music and Visual-Art Related Pleasure - A Critical Integrative Literature Review. Frontiers in psychology, 8, 1218. https://doi.org/10.3389/fpsyg.2017.01218

Appendix

P5.js code (Model 5)

```
// Variables declaration
var song; // Stores the audio file
var fft; // Handles the Fast Fourier Transform analysis for audio
var particles = []; // Array to hold particle objects
var img; // Stores an image file
var noonImage; // Stores another image file for 'noon'
var imgWidth = 90; // Width for the image display
var imgHeight = 90; // Height for the image display
var isPlaying = false; // Flag to track if the song is playing or paused
var currentMovement = 0; // Index to track the current movement pattern
var movementPatterns = []; // Array storing different movement patterns for particles
var noonFrame = -1; // Variable to track frame count for displaying the 'noon' image
var lastColorChangeTime = 0; // Tracks the time of the last color change
var colors = []; // Array to store different colors
var currentColorIndex = 4; // Index to track the current color

// Preloading necessary assets
function preload() {
  song = loadSound('parviz.mp3'); // Loading the music file
  img = loadImage('2-0.png'); // Loading an image
  noonImage = loadImage('noon.png'); // Loading another image
}

// Setup function executed once at the beginning
```

```
function setup() {
  createCanvas(windowWidth, windowHeight, WEBGL); // Creating a canvas with WebGL
  angleMode(DEGREES); // Setting angle mode to degrees
  rectMode(CENTER); // Setting rectangle mode to center
  fft = new p5.FFT(); // Initializing the FFT object for audio analysis
  song.onended(songEnded); // Handling the event when the song ends

  // Storing colors in an array
  colors.push(color(255, 0, 0)); // Red
  colors.push(color(0, 255, 0)); // Green

  // Defining movement patterns for particles
  // Pattern 1: Random movement within canvas bounds
  movementPatterns.push({
    update: function(particle) {
      particle.target = createVector(random(-width / 2, width / 2), random(-height / 2, height / 2));
      particle.update();
    }
  });

  // Pattern 2: Circular movement around the canvas center
  movementPatterns.push({
    update: function(particle) {
      // Setting particle movement based on circular path and music tempo
      // Z-axis movement influenced by the frame count and particle index
      // This movement updates the particle's target position
      // The particle updates its position based on the defined target
      particle.update();
    }
```

```
  });

  // Setting interval to change movement patterns every 3 seconds
  setMovementPattern();
  setInterval(setMovementPattern, 3000);

  // Creating particles
  for (var i = 0; i < 1000; i++) {
    particles.push(new Particle(i));
  }
}

// Draw function continuously executed
function draw() {
  // Setting the background color
  background(0);

  // Analyzing the audio frequency
  fft.analyze();
  var volume = fft.getEnergy(70, 70);

  // Looping through particles, updating movement and displaying them
  for (var i = 0; i < particles.length; i++) {
    var particle = particles[i];
    movementPatterns[currentMovement].update(particle);
    particle.updateColor(volume);
    particle.display();
  }
```

```
  // Check if it's time to display the "noon" image
  if (frameCount == 5 * 60) { // Assuming 60 frames per second
    noonFrame = frameCount;
  }

  // Displaying the "noon" image and applying rotations
  if (noonFrame >= 0) {
    // Applying rotations and tint based on music tempo
    // Scaling and displaying the "noon" image at the center of the canvas
    push();
    translate(0, 0, 0); // Center of the canvas
    rotateX(frameCount * 2.2); // Rotate around X-axis
    rotateY(frameCount * 2.2); // Rotate around Y-axis
    rotateZ(frameCount * 2.2); // Rotate around Z-axis
    tint(255, map(volume, 0, 100, 0, 100)); // Change tint based on music tempo
    var noonSize = 120; // Set the size of the "noon" image
    scale(noonSize / imgWidth); // Adjust the size
    image(noonImage, -imgWidth / 5, -imgHeight / 5, imgWidth, imgHeight);
    pop();
  }
}

// Function to handle mouse click events (play/pause the song)
function mouseClicked() {
  if (isPlaying) {
    song.pause();
    noLoop();
    isPlaying = false;
  } else {
```

```
    song.play();
    loop();
    isPlaying = true;
  }
}

// Function executed when the song ends
function songEnded() {
  song.stop();
  noLoop();
  isPlaying = false;
}

// Function to set a random movement pattern for particles
function setMovementPattern() {
  currentMovement = floor(random(movementPatterns.length));
}

// Particle class definition
class Particle {
  constructor(index) {
    this.index = index;
    this.position = createVector(random(-width / 2, width / 2), random(-height / 2, height / 2));
    this.target = createVector(0, 0, 0);
    this.velocity = createVector(0, 0, 0);
    this.acceleration = createVector(0, 0, 0);
    this.maxForce = 0.05;
    this.maxSpeed = 2;
    this.originalColor = color(random(600), random(0), random(50));
```

```
  this.color = this.originalColor;
  this.scale = 1;
 }

 update() {
  var desired = p5.Vector.sub(this.target, this.position);
  var distance = desired.mag();
  var speed = this.maxSpeed;
  if (distance < 100) {
   speed = map(distance, 0, 100, 0, this.maxSpeed);
  }
  desired.setMag(speed);
  var steering = p5.Vector.sub(desired, this.velocity);
  steering.limit(this.maxForce);
  this.acceleration.add(steering);
  this.velocity.add(this.acceleration);
  this.velocity.limit(this.maxSpeed);
  this.position.add(this.velocity);
  this.acceleration.mult(0);
 }

 updateColor(volume) {
  var c;
  if (volume > 200) {
   c = color(0, random(255), random(255)); // Set color to a random mix of blue and green
  } else {
   c = this.originalColor; // Set color to the original random color
  }
  this.color = c;
```

```
  }

  display() {
    push();
    translate(this.position.x, this.position.y, this.position.z);
    rotateX(frameCount * 5.5 + this.index * 0.1);
    rotateY(frameCount * 0.3 + this.index * 0.1);
    rotateZ(frameCount * 0.3 + this.index * 0.1);
    scale(this.scale);
    noStroke();
    tint(this.color);
    image(img, -imgWidth / 2, -imgHeight / 2, imgWidth, imgHeight);
    pop();
  }
}
```