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Comparison of Guitar and Piano instruments in Kiss the Rain and Bongga Ka Day songs using Fourier Analysis

Flerida Regine F. Cruz[1], Agnes M. Dela Cruz[2], Jovelyn A. Fabricante[3], Hazel Mae R. Diza[4]
Pangasinan State University, Lingayen Campus[1,2,3,4]

Abstract *– This study aims to give an overview of the relationship between mathematics and music by examining the comparison of sound waves produced by the guitar and piano instruments. This study focuses on the waves that represent the sounds of the instruments. Both guitar and piano produce complicated waves, unlike pure tones that produce sine waves or simple sinusoidal waves. The purpose of this study is to use Fourier Analysis as a method to understand the different constituents of sound waves of the individual notes in musical pieces "Kiss the Rain" and "Bongga Ka Day" played by the guitar and piano instruments. This method will help us to easily differentiate the sounds produced by the instruments. The data used in this study were manually recorded using a standard piano and acoustic guitar for consistency. The data were gathered using MATLAB software, a software that combines a desktop environment tuned for iterative analysis and design processes with a programming language that expresses matrix and array mathematics directly.*

Keywords *– Fourier Analysis, MATLAB, Sound Waves*

INTRODUCTION

Music plays a great role in our lives. It expresses a strong feeling and pulls our hearts in the most unusual ways. It is the art of combining both vocal and instrumental sound to produce beauty of form and harmony. It is also an essential aspect of human existence. Like mathematics, music has been an integral aspect of cultures throughout history. Music is everywhere and everything is musical in its own way. It is a language that is universal and is mathematically perfect which means that when we encounter life beyond this planet of ours, we will almost certainly use music to communicate.[4] It is just scratching the surface of how music influences people that expresses their feelings and emotions through music. While listening to different kinds of genres of music it can create sound waves and by using different musical instruments.[1]

A guitar is defined to be an instrument with a long-fretted neck, flat wooden soundboard, flats, and a flat back. It is a plucked stringed musical instrument that probably originated in Spain.[3] A piano is a keyboard musical instrument having wire strings that sound when struck by felt-covered hammers operated from a keyboard. It is also called pianoforte.[5]

These two instruments are found all over the world and compared to other instruments, these are easily accessible. By using one of the most popular music of Yiruma "Kiss the Rain" and Hotdog "Bongga Ka Day" we will be able to know and learn the arrangements of a song.

Fourier analysis is a method of defining periodic waveforms in terms of trigonometric functions. The method gets its name from a French mathematician and physicist named Jean Baptiste Joseph, Baron de Fourier. It is the process of turn a musical instrument sound or any periodic function into its sine or cosine waves portion (Weiss, 2016).[2]

OBJECTIVES OF THE STUDY

This study focused on Fourier analysis of guitar and piano instruments using one of the best-selling and popular music of Yiruma entitled "Kiss the Rain" and Hotdog entitled "Bongga Ka Day". The researchers will be using the Fourier analysis to identify the differences between every harmonics or note in the guitar and piano instruments. This can be understood through exploring the vibrational behavior of the piece "Kiss the Rain" and "Bongga Ka Day" by converting each note to sine functions and graphing them to model the sound that defines it.

MATERIALS AND METHODS

The researchers used Fourier Analysis and MATLAB software to get the time domain, frequency domain to find the differences of the guitar and piano instruments in the Kiss the Rain and Bongga Ka Day music that's been used in this study.

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Fourier Analysis

Fourier analysis is a method of defining periodic waveforms in terms of trigonometric functions. Many waveforms consist of energy at a fundamental frequency and also at harmonic frequencies (multiples of the fundamental). The objectives of the Fourier Analysis is to calculate coefficients a, a_1, a_2, a_3, …, a_n and b, b_1, b_2, b_3,…, b_n up to the largest possible value of n. The greater the value of n (that is, the more terms in the series whose coefficients can be determined) the more accurate is the Fourier-series representation of the waveform.

MATLAB Software

MATLAB is a programming platform and stands for MATrix LABoratory. The heart of MATLAB is the MATLAB language, a matrix-based language allowing the most natural expression of computational mathematics. MATLAB is a high-performance language for technical computing. It integrates computation, visualization, and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation.

Using MATLAB, the researchers generate the soundwaves of the guitar and the piano instruments using the songs Bongga Ka Day and Kiss the Rain in computing the time domain and the time-frequency of the songs.

RESULTS AND DISCUSSION

This chapter presents the resulting graph produced by notes in a pure sinusoidal wave. Together with some mathematical concepts and examples that were discussed in a more precise explanation with the use of the previous definition.

In graphing the pure sinusoidal waves of a given musical piece, the researchers need to write down all the notes and their equivalent frequency. The Scientific Pitch Notation or SPN is used to identify the exact musical pitch using the musical note name and the number which determines the pitch's octave.

Table 1 shows the 6 different notes in the musical piece of Kiss the Rain in C with their equivalent frequencies. The frequency of every note was composed using the formula for the frequency of musical notes with A_4=440 Hz as a fixed note since we are using the equal-tempered scale as standard tuning. This table shows the notes of the song Kiss the Rain with their corresponding semitones and frequencies.

Table 1: Musical Notes and the Frequency of Kiss the Rain

Notes	Semitone	Frequency
A_4	0	440.00
D_4	7	293.66
E_4	5	329.63
F_4	3	349.23
G_4	2	392.00
C_4	12	261.63

Table 2: Musical Notes and the Frequency of Bongga Ka Day

Notes	Semitone	Frequency
C_5	11	523.25
$C^{\#}_5$	1	554.37
D_5	2	587.33
$D^{\#}_5$	3	622.25
F_5	4	698.46
G_5	6	783.99
$G^{\#}_5$	7	783.99
A_5	9	880.00
$A^{\#}_5$	10	932.33

Table 2 shows the 9 different notes in the musical piece of Bongga Ka Day with the equivalent frequencies.

Graphs of the pure sinusoidal wave of the musical notes in kiss the rain. The graph of musical notes shows the ideal waveform formed by a single frequency. The higher the pitch of the note, the higher the frequency is and the more cycle it will produce. The frequency and the period of the wave had an inverse relationship.

After applying Fourier analysis to the complex waveform of the sound produced by the guitar and piano, this study revealed that the sound does not only consist of the fundamental frequency (which determines the pitch) but also integer multiples of the fundamental frequency or harmonic overtones (which determines the timbre). The presence of these additional harmonics together with their differing amplitudes veers away

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from the sound produced by the instruments from being monotonous. In this study, the researchers found out that the time-frequency and the frequency domain of every note are connected. The researchers showed the different waves by the musical notes.

Furthermore, the amplitude of the fundamental frequency of the individual note in musical pieces "Kiss the Rain" and "Bongga Ka Day" played by the guitar and piano instruments, in most cases, appears to be lower than the amplitude of its harmonic overtones. This happens when the notes of Kiss the Rain which areA_4, D_4, E_4, F_4, G_4, and C_4 and also the notes of Bongga Ka Day which are C, C#, D, D#, F, G, G#, A, and A# are played by the guitar and piano instruments. So here is the comparison of the songs using guitar and piano instruments.

Figure 1 shows the waveform of the song Kiss the Rain played by the piano instrument using Fourier analysis and MATLAB software.

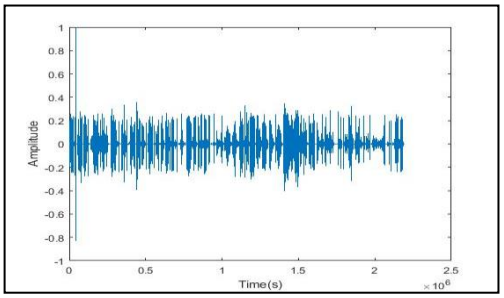

Fig. 1 Kiss the Rain waveform played by the piano instrument

Figure 2 shows the waveform of the song Kiss the Rain played by the guitar instrument using Fourier analysis and MATLAB software.

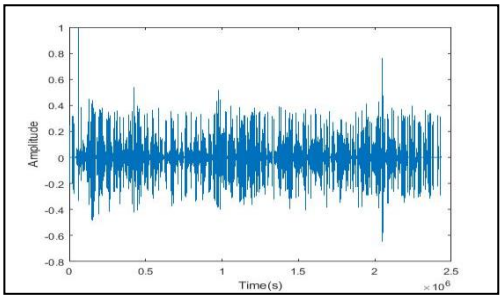

Fig. 2 Kiss the Rain waveform played by the guitar instrument

Figure 3 shows the waveform of the song Bongga Ka Day played by the piano instrument using Fourier analysis and MATLAB software.

Figure 4 shows the waveform of the song Bongga Ka Day played by the guitar instrument using Fourier analysis and MATLAB software.

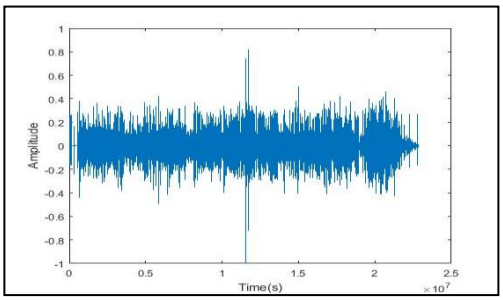

Fig. 3 Bongga Ka Day waveform played by the piano instrument

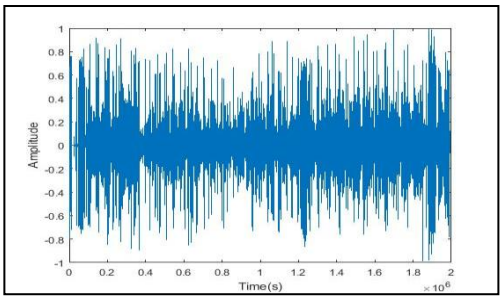

Fig. 4 Bongga Ka Day waveform played by the guitar instrument

Figure 1 to figure 4 presents the waveforms of the songs Kiss the Rain and Bongga Ka Day using guitar

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and piano instruments using MATLAB. This shows that from the given chords or notes we can create a waveform. Notice that from the figures, we can show the differences in the music Kiss the Rain and Bongga Ka Day using different kinds of instruments.

CONCLUSION AND RECOMMENDATION

The researchers decomposed the sound waves of guitar and piano represented in the Fourier series. Thus, from complicated sinusoidal wave which was illustrated in time-domain, it was converted to a frequency domain using Fourier transform. Fourier analysis was used to determine the harmonics (fundamental harmonic and harmonic overtones) in each note, to model sound, and to define sound by breaking it up into pieces. Every note played by an instrument like guitar and piano has different harmonics and amplitudes. The higher the note being played in the instruments, the lower the harmonic content. Inversely, the lower the note being played in the instruments, the higher the harmonic content. Their individual amplitudes vary in each harmonic from the given note.

After applying Fourier analysis to the complex waveform of the sound produced by the guitar and piano, this study revealed that the sound does not only consist of the fundamental frequency (which determines the pitch) but also integer multiples of the fundamental frequency or harmonic overtones (which determines the timbre). The presence of these additional harmonics together with their differing amplitudes veers away from the sound produced by the instruments from being monotonous. In this study, the researchers found out that the time-frequency and the frequency domain of every note are connected. The researchers showed the different waves by the musical notes.

Furthermore, the amplitude of the fundamental frequency of the individual note in musical pieces “Kiss the Rain” and “Bongga Ka Day” played by the guitar and piano instruments, in most cases, appears to be lower than the amplitude of its harmonic overtones. This happens when the notes of Kiss the Rain which areA_4, D_4, E_4, F_4, G_4, and C_4 and also the notes of Bongga Ka Day which are C, C#, D, D#, F, G, G#, A, and A# are played by the guitar and piano instruments.

To improve the reliability of the data and to have detailed comparisons between different instruments, the recordings could be repeated on guitar and piano and take their average since guitar and piano also have slightly different timbre. Moreover, future researchers can use Fourier Analysis in composed music and changed timbre of the sounds they are creating. They can also use Fourier in determining the differences between the new music and old music. They can also use Fourier analysis to find the peak of every note. Thus, they could create entirely new sounds and note confined by the physical capabilities of musical instruments. Aside from this, the future researchers can also use Fourier Analysis to determine all notes in piano and identify the differences between them and how frequencies work. They can use different notes on the original music. They can use Fourier Analysis to different types of genres in music. Hence, they could also use Fourier Transform to add filters in their music.

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PLEASE INCLUDE CONTACT INFORMATION:

NAME: FLERIDA REGINE F. CRUZ
CONTACT NO: 09182326679
EMAIL ADDRESS: FQFERNANDEZ1@UP.EDU.PH

NAME: HAZEL MAE R. DIZA
CONTACT NO: 09777537328
EMAIL ADDRESS: HMDIZA.LINGAYEN@PSU.EDU.PH