The Frequency Spectrum and Time Frequency Analysis of Different Violins Classification as Tools for Selecting a Good-Sounding Violin

Sinin Hamdan[1], Ahmad Faudzi Musib[2], Marini Sawawi[1] and Saiful Hairi Othman[3]*
[1]*Faculty of Engineering, Universiti Malaysia Sarawak, 94300 Kota Samarahan, Sarawak, MALAYSIA*
[2]*Faculty of Human Ecology, Universiti Putra Malaysia, 43400 Serdang, Selangor, MALAYSIA*
[3]*Institute of Creative Arts and Technology, Universiti Malaysia Sarawak, 94300 Kota Samarahan, Sarawak, MALAYSIA*
*Corresponding author: hosaiful@unimas.my

Published online: 27 December 2021

To cite this article: Sinin Hamdan, Ahmad Faudzi Musib, Marini Sawawi and Saiful Hairi Othman. 2021. The frequency spectrum and time frequency analysis of different violins classification as tools for selecting a good-sounding violin. *Wacana Seni Journal of Arts Discourse 20*: 27–40. https://doi.org/10.21315/ws2021.20.3

To link to this article: https://doi.org/10.21315/ws2021.20.3

ABSTRACT

This work evaluates four violins from three distinct manufacturers, notably Eurostring, Stentor, and Suzuki, using a scientific approach. Eurostring1 and Eurostring2 were the names given to the two Eurostring units. The purpose of this study is to identify elements in various violins that could be used as tools for selecting a pleasant-sounding violin by having them classified by a professional violinist. The signal's time varying frequency was evaluated using a frequency spectrum and a time frequency plane, and the combination of frequency spectrum and time frequency domain is utilised. PicoScope oscilloscopes and Adobe Audition version 3 were used to record the acoustic spectra in terms of time and frequency. The time frequency plane is identified, and time frequency analysis (TFA) is produced by Adobe Audition spectrograms. The sound was processed in order to generate Fast Fourier Transform analysis: Fourier spectra (using PicoScope) and spectrograms (using Adobe Audition). Fourier spectra identify the intensity of the fundamental frequency and the harmonic spectra of the overtone frequencies. The highest frequencies that can be read are up to and including the 9th overtone. All violins have a constant harmonic overtone pattern with an uneven acoustic spectrum pattern. Eurostring1 showed inconsistent signal in the string G with 6th and 7th overtone missing, whereas Eurostring2 lack of the 6th overtone. Among the string D, only Eurostring1 display an exponential decay for the overtone. All the string A except for Suzuki showed nice and significant peak of fundamental and overtone. Stentor displays up to the 5th overtone. Among the string E, Suzuki showed inconsistent harmonic peak intensity. TFA revealed that the fundamental frequency of string E for Eurostring1 was lower than the first overtone. Only Eurostring1 has an uneven decay for the overtone frequency, whereas Eurostring2 exhibits a large exponential decay for the overtone frequency.

Keywords: *acoustic spectra, frequency spectrum, harmonic overtone, time frequency analysis, violin instrument classification*

INTRODUCTION

Any periodic sound wave should be heard as a sum of sinusoidal components or partial with their corresponding pitches. A complex tone is the sum of sinusoidal components or partial which are harmonics (Plomp 1976). In general, a typical musical tone consists of a large number of harmonics with frequency ratios 1:2:3:4:5 etcetera. The sound of music instrument results in the sensation of a single note with a single definite pitch equal to the pitch of the fundamental and a specific timbre depending upon the relative amplitude of the harmonics. Hence, the sound intensity of the instruments is different between violins. In this paper, we investigate the comparison between frequency of four violins using PicoScope Oscilloscope and Adobe Audition version 3. The physical parameters of the tone that were analysed are the sound pressure level and frequency. The sensation of tone measured by the PicoScope is only the pitch, while the loudness and timbre are detected by the Adobe Audition. The relationship between time and frequency has been well-established, which include the study of the sound that coincides with the Fourier analysis. Fourier analysis yields the frequency content and associated time frequency analysis (TFA) to understand the sound. The purpose of this work is to study the pure tone signal and TFA in four violins sound. Fast Fourier Transform (FFT) performs a TFA of an input signal by bowing the violin string. The time frequency content of the signal is visualised by creating a spectrogram image, which is done by Adobe Audition. This spectrogram is used to identify the pitch of the sound produce by the signal. The output is a time frequency with time varying according to the frequency content of the signal. Understanding the spectra and spectrogram properties gives the pitch based on the equal tempered scale.

Issues or Problem

Since the human ear is not capable of distinguishing the individual harmonics of a complex tone, the identification of the partials may be nearly impossible in listening to tones in a musical context (Plomp 1976). There have been many features offered to represent musical signals which also targeted to reveal the differences of instrument sounds (Herrera-Boyer et al. 2003, 2006; Deng, Simmermacher and Cranefield 2008; Essid, Richard and David 2006; Klapuri and Davy 2006). While the temporal evolution of the signal is characterised by the time-based features, the spectral features are extracted using spectrum based on the FFT. The frequency spectrum is a very popular frequency analysis techniques, and it is widely used for the non-stationary signals in which the statistical properties vary with time (Mallat 2009). The time varying frequency of the signals is observed in a time frequency plane with the continuous wave analysis where the signal is divided into the fundamental and overtone frequency which varies with time. Accordingly, the use of frequency in musical signals may be separated into two cases based on the following representations. In one representation, the emphasis is given to the extraction of instantaneous frequency from the sinusoidal wave. The instantaneous frequency of a signal can be extracted using FFT displayed as amplitude frequency. These characterise the frequency modulation of the signals. The other frequency representation involves with the time frequency plane. The pitch frequency features have been extracted for audio including musical instrument sounds (Lin et al. 2005). As the study is focused on time frequency representations, the comparison is given to the results with different time functions.

Why is This Study Carried Out?

The organisation of the article is as follows: Section 2 reviews the method of obtaining the frequency spectrum signal and time frequency plane. The experimental study was performed for different violin manufacturers. It is accepted that the starting transients are the most important part of the signal for the recognition of musical sounds (Kostek 2005). Therefore, a frame length consisting of 2,048 samples were selected from the attack part of the musical instrument sounds. Finally, the corresponding results using the experiment were compared to the conclusions made by a professional violin player.

What is the Main Focus?

The primary focus of this article is on representing musical signals with time frequency features that are effective due to the nature of musical signals, in which the frequency varies with time. While the frequency spectrum is likely to yield an acceptable recognition rate, it lacks the temporal dimension of timbre, which is critical in distinguishing violins. That explains why, in addition to the frequency spectrum, time varying frequency is used. Although the primary goal is to classify violin instruments, the note of the violin can be determined by comparing the frequency distribution with time to the frequencies in the harmonics.

Why Do We Need to Know about This Topic?

This is an extremely important topic because only professional violinists can determine what constitutes a good sound violin. However, the term “good” is very relative, and the need is evident not only from hearing. A musician’s ear will never be the same as that of an ordinary person who does not recognise proper pitch. In this work, we identify the fundamental and harmonic of each violin, as well as the regularity of each.