EuroRegio2016
June 13-15, 2016
Porto ▪ Portugal

Impact of a guitar string pluck on the instruments tone

Jerzy Wiciak, Paweł Małecki, Daniel Tokarczyk

Department of Mechanics and Vibroacoustics, AGH University of Science and Technology,
al. Mickiewicza 30, 30-059 Kraków
danielt@agh.edu.pl

Abstract
Guitar is a string instrument in which sound is produced by a pluck of the string. The obtained sound is dependent on many factors. The method of plucking is one of the important elements that shapes the final sound of the guitar.
The following article concerns the research on the influence of the position of plucking point and the angle of guitar pick attack on the string and its influence on the instrument tone shaping.

Keywords: robot, guitar, sound

PACS no. 43.75.+a, *43.75.-z

1 Introduction

Guitar is a chordophone string instrument. There are many factors that affect the tone of a guitar. Those factors among others are: type of wood used to produce the guitar, size and shape of the instrument, type and tension of the used strings [1]. Musician is another important factor. The angle, point and the force inputted for the string pluck has a strong influence on the obtained sound [2].
Research on the effect of guitar string pluck on the sound coming out of the instrument, requires a proper pluck repeatability to eliminate human imperfection. In this case repeatability refers to time intervals between the played sounds. For the purposes of the presented research a guitar playing robot was used. The application of an artificial musician was necessary, because of the low level of repeatability obtained by a human musician [3]. For the research purposes a robotically embedded test stand has been built. The robot was equipped in a movable plucking module, that could move along string axis between the guitar bridge and neck.

2 Applied test stand

The test stand created for the purpose of the research was designed to repeatedly excite the guitar strings. It consisted of the following elements:

- Guitar string excitation robot
- Recording equipment

The used robot was built as an easy to modify and repair device. It is composed of two modules:

- Microcomputer equipped with author's designed electronics – modules purpose was to control the robot (Fig. 1)
- Electro - mechanical plucking module – used to excite the string (Fig. 2)

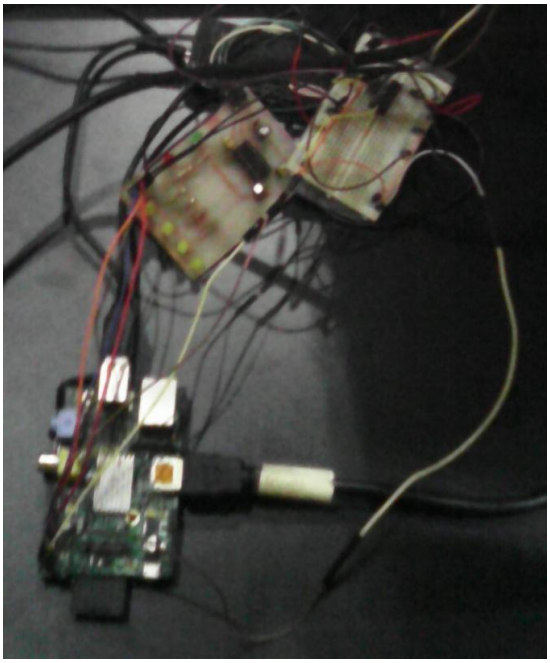

Figure 1 – Robots control module.

The main advantage of the used robot is the movable string plucking element. It's application provided a possibility of precise movement over the guitar string axis to preferable pluck positions.
Microcomputer used to control the robot was Raspberry Pi[4].
The used robot was based on the original project used for research on a guitar tone [5].

Figure 2 – Robots plucking module.

3 Research methodology

3.1 Theoritical string pluck

In theory, pluck of a perfect string generates an output signal with some unique properties. After a pluck is made in 1/5 of the string length (measured from the bridge fixed mounting point), one can observe lack of the fifth harmonic and its multiplications in the output signal (Fig 3.). Analogically if a string is plucked in its third the length of the string, the third harmonics is missing.

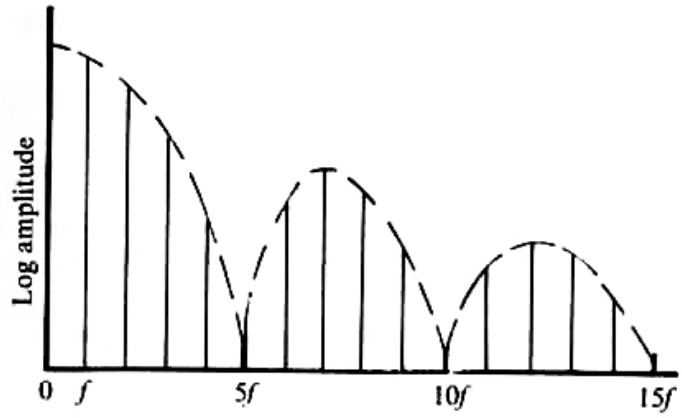

Figure 3 – Spectrum of a string plucked in 1/5 of its length [6]

3.2 Research issues

- Is the sound produced by the instrument dependent on the plucking position?
- Is the sound produced by the instrument dependent on the plucking angle?

To obtain the answers for the given questions, the spectrum peak values distances and spectral analysis obtained from Fast Fourier Transform were used.

3.3 Research procedures

The research was conducted in the anechoic chamber. The sample data was recorded with a condenser Studio Project C4 microphone and ZOOM R24 sound recorder.
At the beginning of the research, the robot was calibrated and mounted on the guitar. The microphone was placed according to the guitar recording standards [7]. The robot mounting points were marked to avoid any dilatations that could affect the validity of obtained sound samples.
The research was split into two cycles (each for the tested pluck angle). Both cycles were performed on exactly the same guitar parameters. Each cycle was split into thirty stages. The steps performed for every stage of the research are shown in Figure 4.

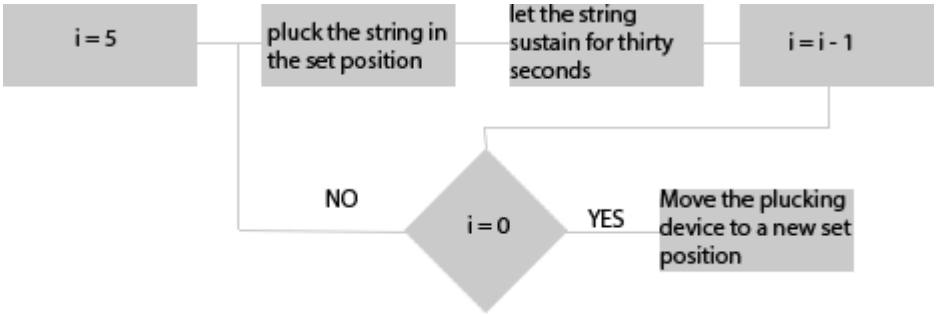

Figure 4 – The algorithm shows steps performed for all stages of the research

4 Results

In order to obtain spectra of the recorded samples, Fast Fourier Transform was used [8]. The research results contain the spectral analysis.
By comparing the spectra obtained by plucking the string in the same position, but with different angle (0^0 and 45^0 with the respect to the string axis) one can clearly see that the obtained tone differs (Fig. 5). The differences in the sound produced by plucking the string at different angles can be easily explained. The pluck at 45^0 had a greater point of contact and the string was excited and suppressed at the same time.

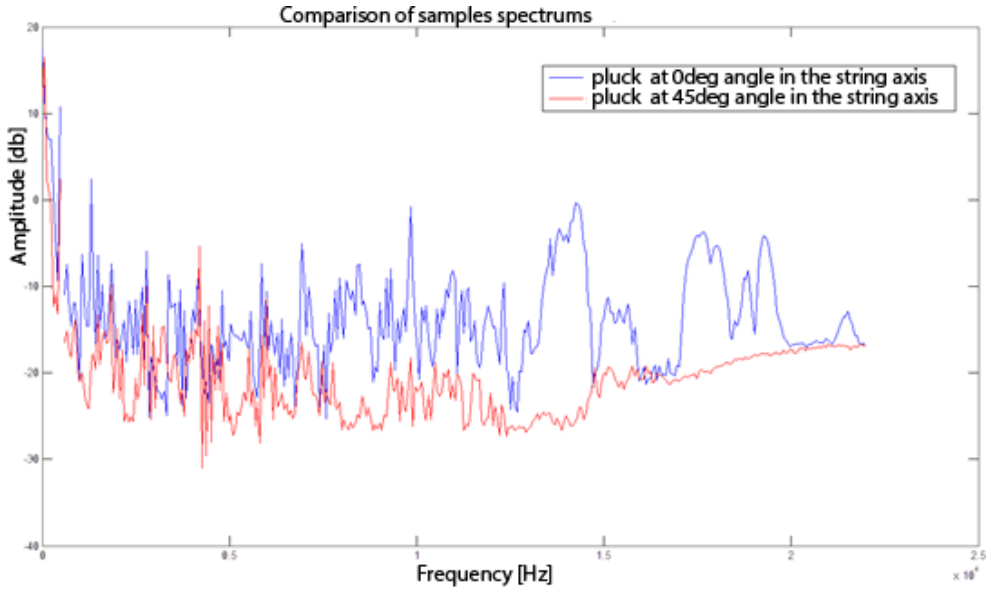

Figure 5 – Two samples that had different pluck angle, set on one graph for comparison purposes

Spectrograms of the recorded samples (Fig. 6.) were used to determine the influence of the plucking position on the final guitar tone. It can be clearly seen that depending on the position in which the string was plucked, variability in the sound occurs. The main difference between the samples is the density of occurring frequency bands. When the distance of the pluck goes further from the guitar bridge, the density of the bands was lesser, but more higher frequencies could be observed.

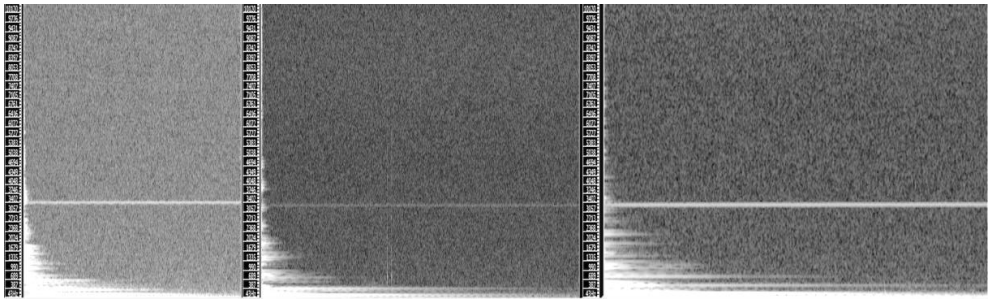

Figure 6 – Spectrograms of the samples plucked at 00 in different points. The left diagram represents the position closest to the guitar bridge. The middle diagram shows represents the pluck halfway between the bridge and the neck. The right diagram represents the pluck above the guitar resonant hole. Y axis represents frequency [Hz] and X axis represents time [s]

5 Conclusions

During the research necessary repeatability was obtained witch let the gathering of proper samples that gave meaningful results. The issues that have been raised were successfully solved and it has been proven, that the plucking position and angle is crucial to the produced sound by the guitar.

References

[1] Kamiński W., Świrek J., Lutnictwo. Wstęp do sztuki lutniczej. Warszawa, Polskie Wydawnictwo Muzyczne, 1972.

[2] Błaś K., Żadnych tajemnic. Wrocław, Wydawnictwo Muzyczne Absonic, 2012.

[3] Tokarczyk D., A guitar playing robot, Masters dissertation, Akademia Górniczo-Hutnicza, 2014, 8.

[4] Upton E., Halfacree G., Raspberry Pi User Guide, 3rd Edition. Chichester, John Wiley & Sons, 2014.

[5] Tokarczyk D., Stanowisko do badań wpływu elementów składowych gitary na jej barwę. W: Postępy akustyki 2015 red. Opieliński K. J. Wrocław, Polskie Towarzystwo Akustyczne. Oddział we Wrocławiu, 2015.

[6] Fletcher, N.H., Rossing, T.D., The Physics of Musical Instruments, Springer-Verlag, 1998.

[7] Sztekmiler K., Podstawy nagłośnienia i realizacji nagrań. Warszawa, Narodowe Centrum Kultury, 2003.

[8] Van Loan Ch., Computational Frameworks for the Fast Fourier Transform, Philadelphia, SIAM, 1992.