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Digital Models for Assessing the Relationship of Economic and Ecological Processes with Musical Works

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ABSTRACT

The development of the digital economy, associated with the diffusion of new technologies, as well as new management models in many industries, can bring significant economic benefits, which include not only cost reduction and revenue growth, but also a reduction in risks arising, for example, in the process of analyzing audio signals. Positive examples are already described by scientists and practitioners in the field of healthcare, agriculture and trade. The purpose of the article is to analyze the impact of environmental signals and musical work using innovative, information technologies. Based on the correlation processing of the spectra of musical works by famous composers, a high level of their connection with low-frequency fluctuations of the microwave radiation of the Sun reaching the Earth's surface is proved. The revealed regularity can be interpreted so that the works of famous musical works are nothing more than a reflection in the author's processing of real natural processes, which include the fluctuations of the microwave radiation of the Sun. The result can be used as the basis for substantiating the necessary procedure for determining certain musical works for their use for medicinal purposes. The wavelet transform is a mathematical tool that provides a constant Q factor in the spectral analysis of signals. It is used for spectral analysis of a signal along with the Fourier transform, a classic example of a spectral analysis tool. In modern professional audio processing applications, various methods of signal transformations are widely used to create high-quality effects. Thus, it is effectively used to analyse musical signals, as frequencies on a musical scale are separated logarithmically. The advantages of the introduced correlation function over other correlation functions are noted, in particular, the ability to analyse not only temporal, but also frequency correlations of unsteady signals.

Keywords: *spectrogram, continuous wavelet transform, characteristic of a signal, non-stationary signals, sound signals, spectral analysis*

1. INTRODUCTION

In the world and in recent years, the tendency to strengthen the priority of preserving human health in solving environmental pollution problems has been increasingly clearly seen. This trend is largely associated with the recognition of the importance of socio-economic harm and damage from environmental degradation for the quality of life and the development of human potential. The direction to include the health factor in the development of environmental policy, greening the economy, and the transition to sustainable development is becoming increasingly important in the process of making specific decisions and developing national strategies, programs and projects [1-2].The development of nature-friendly technologies for the prevention and treatment of a wide range of human diseases is one of the promising directions for the development of the global healthcare system. Wavelet transform (WT) is a relatively new effective technology that allows processing various types of signals [3-5]. Having a number of advantages over traditional types of transformations, have found application in the field of encoding video data and images. In addition, there are many studies on the use of WT for sound compression, during which it was shown that this type of function allows you to highlight various characteristics of audio signals. This property makes it possible to use WT for the analysis of sound data with subsequent the use of the obtained information not only for their compression, but also for solving a number of other tasks [6-8]. The complexity of the implementation of this direction is due to the unsolved problem of understanding the mechanism of natural regulation, which provides homeostasis of the body, determining its main sources during the evolution of wildlife, as well as the reasons for its weakening in modern conditions. An important factor in influencing the homeostatic functions of the body is the acoustic background of natural origin [9,10]. It is a collection of weak mechanical disturbances of various physical nature propagating in an elastic medium. Audible sounds are an important source of information for wildlife, affecting their regulatory functions. This pattern is reflected in the use of musical works by famous composers, primarily V.A. Mozart for the prevention and treatment of a wide range of psychosomatic diseases that develop in the body as a reaction to stress [11-14]. Gregorian chants, as well as the works of I.-S., are recognized as close in therapeutic effect. Bach, A. Vivaldi, G. Handel, P. I. Tchaikovsky, F. Chopin, F. Schubert, R. Schumann and others. Numerous studies have established that under the influence of these musical works stimulation of the immune system is carried out, partially due to the necessary synthesis of dopamine for the correction of many mental processes. Getting pleasure from listening to music is also associated with the production of oxytocin by the brain, which acts as a soft drug. A number of researchers attribute the positive effect of listening to music with its consistency with part of the high-frequency biorhythms of the human body. Despite the large amount of information about the therapeutic effect of the above music in the treatment of psychosomatic diseases of a person, there is no complete understanding that certain musical works have the necessary effect on the body [15,17]. Also, the evolutionary mechanism of the high governing role for the organisms of these musical works is not clear. To solve these problems, it is necessary to conduct a comparative spectral analysis of musical works with real processes of natural origin, which are associated with the evolution of organisms and humans, in particular. In this paper, we analyse two new approaches to the analysis of non-stationary, audio signals. The first approach is based on the introduction of an adaptive Morlet wavelet, which allows you to change the frequency and time resolutions of the studied signals using this method. The second method involves the use of a correlation function, which two is the correlation of continuous wavelet transforms of two signals, calculated both in frequency and in time [18-20]. The article presents the results of the analysis of sound signals and the correlation with low-frequency variations of the microwave radiation sun - MRS.

1. Time response signal

The main directions of this method are continuous and discrete wavelet analysis. The result of continuous wavelet analysis of a certain signal defined by the function $f(t)$ will be the function $Wf\ (a,\ b)$, which depends on two variables - the coordinate b and the scale a [20, 21].
A strict definition looks like this:

$$Wf\,(a,b) = \frac{1}{\sqrt{a}} \int_{-\infty}^{\infty} \psi\left(\frac{t-b}{a}\right) f\,(t)dt \qquad (1)$$

1.1. The choice of studied musical works.

It is known that MRS - (microwave radiation of the Sun) can have a positive effect on human homeostasis. Scientists around the world are studying this issue. There are medical devices "AIMT-1" (Information Microwave Therapy Apparatus, based on the generation of MIS, which are used for healing purposes [22]. There is also the fact that musical works influence the human body, its mood and regulatory functions. In this connection, there is an assumption about the possibility of combining two signals in order to obtain radiation modulated by the law of a musical work in this paper, we analyse several musical works that were studied in order to find the max a similar resemblance to low-frequency MRS variations.

2. Experimental part

During the experiment, a temporal response and a spectrogram of these signals were obtained. The analysis of the time characteristic and the spectrogram of the indicated musical works (Fig. 1.1 - 8.1) indicates the presence of general patterns and small amplitude differences in their frequency distribution.

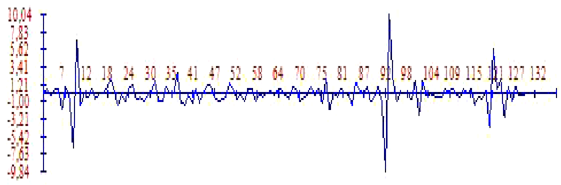

Figure 1 Time characteristic of the MRS

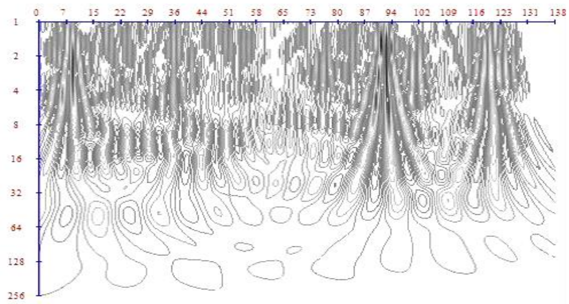

Figure 1.1 Spectrogram MRS

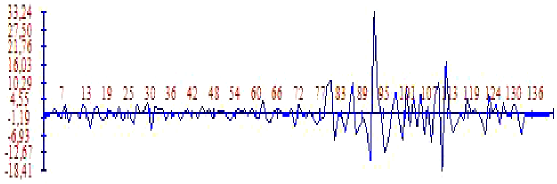

Figure 2 Time characteristic of the music of W. A. Mozart "Symphony No. 4"

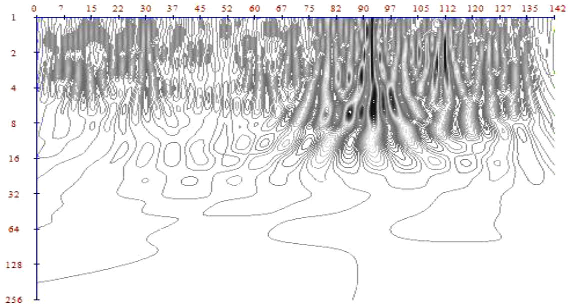

Figure 2.1 Spectrogram music by V. A. Mozart "Symphony No. 4"

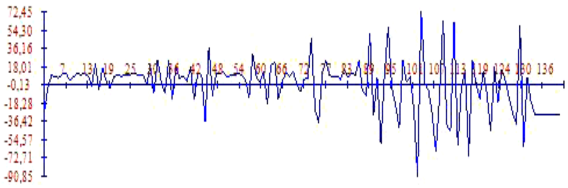

Figure 3 Time characteristic of J. S. Bach's music "Toccata and Fugue in D minor"

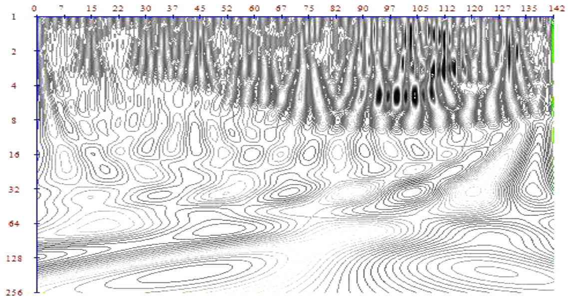

Figure 3.1 Spectrogram music by J. S. Bach "Toccata and Fugue in D minor"

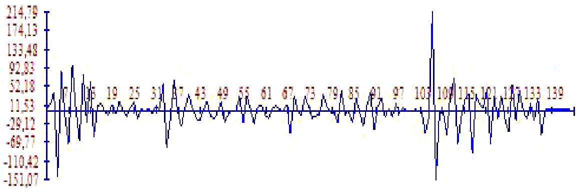

Figure 4 Time feature music by Vanessa may " Toccata and Fugue in D minor in modern treatment»

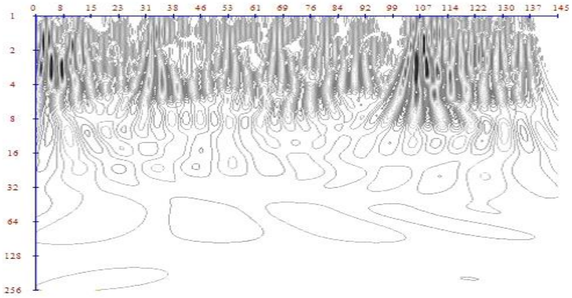

Figure 4.1 Spectrogram music by Vanessa may " Toccata and Fugue in D minor in modern processing»

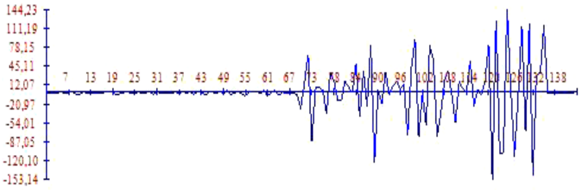

Figure 5 Time characteristic of the music "Rammstein Du Hast "

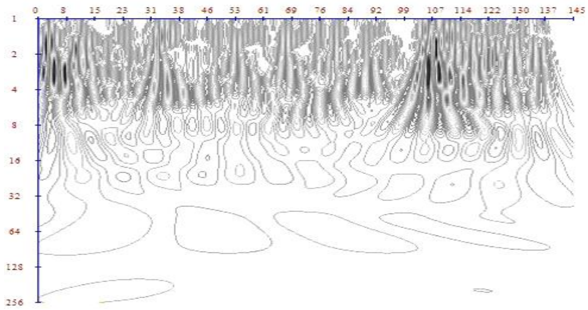

Figure 5.1 Spectrogram of music "Rammstein Du Hast»

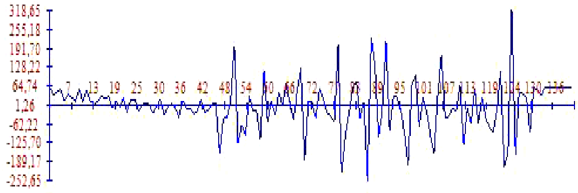

Figure 6 Time characteristic music " Heavy rock-in German»

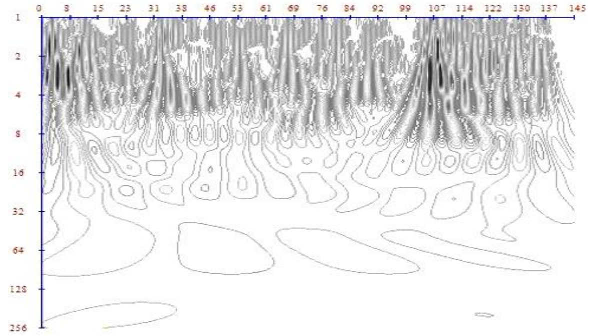

Figure 6.1 Spectrogram music " Heavy rock-in German»

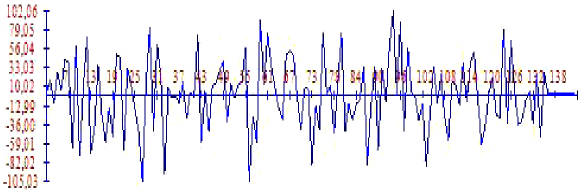

Figure 7 Time characteristic “White noise”

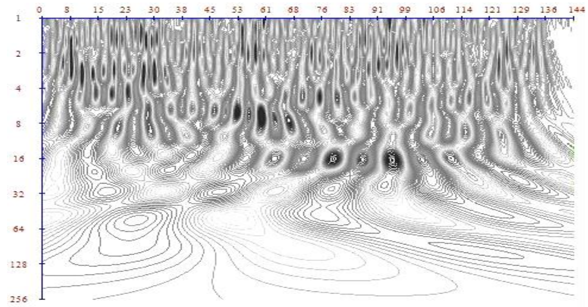

Figure 7.1 Spectrogram “White noise”

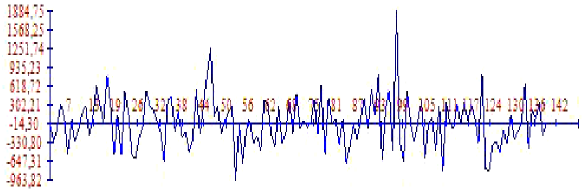

Figure 8 Time characteristic “Pink noise”.

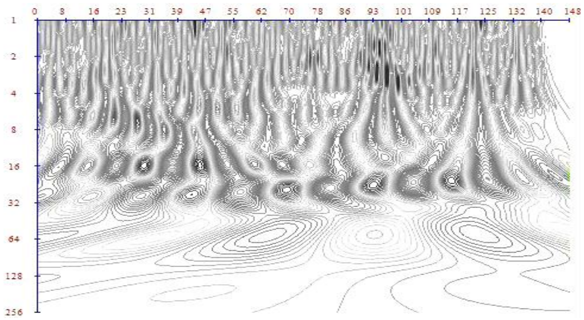

Figure 8.1 Spectrogram “Pink noise”.

Of the above emissions, the priority control role belongs to microwave radiation, which reaches the Earth's surface 8 minutes after the start of radiation. The information component of this radiation is associated with its low-frequency fluctuations. A hypothesis is known that it is these fluctuations that underlie the formation of its neural regulation mechanism in the process of evolution of an organism [22]. The complexity of the instrumental measurement of real fluctuations in the microwave radiation of the Sun reaching the Earth’s surface was determined by studies to substantiate their model.

The result of such studies was the justification of the structure of low-frequency fluctuations, which are a continuous random sequence of discrete ΔTi with a duration of ΔTi = (0.01 ... 10) s, within which the oscillation frequency varies at different speeds linearly in the range of sound frequencies (rate of change of frequency in each sample, dF / dt and the initial frequency F0 lie in the range of values dF / dt = ± (5 ... 200) · 103 Hz / s and F0 = (20 ... 20,000) Hz, respectively) (Figure 1-1.1) [23-26].

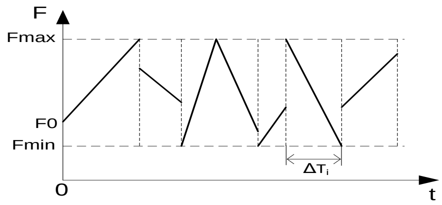

Figure 9 Time-Frequency structure of the model of low-frequency fluctuations of microwave radiation from the Sun

3. Calculation of the mutual similarity of audio signals.

To determine the mutual similarity of audio signals, a program was developed in the C # programming language using wavelet transform. In this section of the article, the results of experiments on finding the correlation function of the frequency spectrum of the signals of various musical works with the spectrum of calm solar radiation were obtained. For any signals M_a *(t)* and M_b *(t)*, one can introduce a correlation function (KKF) [27,30]

$$KKF_{ab}(t) = \int_{-\infty}^{\infty} M_a(t')M_b(t+t')dt' \qquad (2)$$

The function KKF_{ab} *(t)* characterizes the relationship between signals taken at different points in time.

3.1. Conclusions on correlation functions.

Based on the experiment, the average correlation coefficient of each piece of music with MRS was calculated. The data are shown in table 1.

Table 1 The average similarity coefficient

The name of the piece of music	Correlation coefficient %
V.A. Mozart “Symphony No. 4”	72
J.S. Bach "Toccata and Fugue in D minor"	67
Vanessa May "Toccata and Fugue in D minor in a modern twist"	71
Rammstein Du Hast	63
Hard Rock - in German	67
White noise	47
Pink noise	48

Distinguishing features of the correlation function of each signal in the entire frequency region of the spectrum were highlighted. The greatest correlation coefficient is possessed by the musical work of V.A. Mozart “Symphony No. 4”, by Vanessa May “Toccata and Fugue in D Minor in Modern Processing”. This fact suggests that in the frequency domain, Mozart’s music is quite strongly correlated with Vanessa May “Toccata and Fugue in D minor in modern processing”. Thus, it is allowed to conclude that the music of Mozart has the same calming and pacifying effect as Vanessa May "Toccata and Fugue in D minor in modern processing".

3. CONCLUSION

In table 1 shows the results of calculating the correlation coefficient of the spectra of the presented musical works with the MIS spectrum should be considered unexpected, since they reflect a previously unknown high degree of correlation. Based on the revealed regularity, it follows that the works of famous composers can be considered as a reflection in the author's processing of real natural processes, which may include. The result can be used as the basis for substantiating the necessary procedure for determining certain musical works for their use for medicinal purposes. For this, software was developed in the C # programming language to evaluate the time and frequency components of various genres of musical works, and correlation functions and the correlation coefficient of each genre with MRS were found. The following genres of musical works participated in the experiment:

- V.A. Mozart “Symphony No. 4”
- I.S.Bach “Toccata and Fugue in D Minor”
- Vanessa May "Toccata and Fugue in D minor in modern processing"
- Rammstein Du Hast)
- Hard rock - to German
- White noise
- Pink noise

classical music (representative - V.A. Mozart with the work. V.A. Mozart has the greatest similarity among these musical works with MRS with a result of 72%. According to his law, the carrier oscillation of the device was used to correct the regulatory functions of the human body. For comparative The estimates in Table 2 show the results of calculating the MRS correlation, as well as with the low-frequency analogue of the “white” and “pink” noises. They reflect a low correlation with natural low-frequency fluctuations of e electromagnetic radiation of natural origin.

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