Dynamic properties of musical signals in genre Ethnic Electronica

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Abstract - **This paper presents dynamic properties of musical signals obtained from various artists and groups referred to as Ethnic Electronica composers. The signal database consists of more than three hours of music. Each song is filtered by seven octave-band filters and statistical data are analyzed inside each octave band. Effective value, time variation of the signal level, probability and cumulative distribution, numerical indicators of dynamic properties, descriptors of the shape of probability distribution and musically relevant dynamic range for each octave are found. The paper contains detailed statistical properties for all seven octave bands based on the music database of musical genre Ethnic Electronica. Some results are compared to the results obtained from Jazz and Blues genre.**

Key words – musical signals; dynamic properties; octave-band filters; ethnic electronica;

I. INTRODUCTION

Studies in the field of dynamic characteristics of audio signals are very important and many engineers deal with problems in such topics. The importance is reflected in engineering approaches such as volume control in sound reproduction, audio coding algorithms, methods for the restoration of old records, determination of amplifier power for sound reproduction, microphone and loudspeaker design etc [1].

There are a number of papers which present dynamic properties of audio signals. Different signals from various musical pieces were studied such as speech, musical instruments and other complex musical sources. Considering many of the presented results were published in the last century, some of them contain limits in the technology for sound recording and signal analysis. Further, limits in the results originate from the relatively small music database and the fact that statistical data are not detailed enough. All musical genres are not included as well, particular modern genres which combine elements of electronic music and other musical styles. For all these reasons, the engineering approach to the dynamics of audio signals requires more precise quantitative data [2], [3], [4].

This paper contains detailed statistical data resulting from processing of audio signals of musical genre Ethnic Electronica. Ethnic Electronica, also known as Ethno Electronica or Ethno-Techno, combines elements of Electronic and World Music and was developed in the nineties. The term Ethnic Electronica appears in music magazines, in online music-related forums and blogs and also in a title of a 2003 compilation "Another Life: A Journey Into Ethnic Electronica" (Love Cat Music). The term Ethno-Techno was first seen with the release of "Ethno-Techno: Sonic Anthropology Vol 1" Wax Trax! in 1994 [5].

Notable acts of Ethnic Electronica include Bryn Jones with his project Muslimgauze, the artists of Asian underground movement such as Asian Dub Foundation, State of Bengal, Transglobal Underground, Natacha Atlas. The other important acts include Mozani Ramzan, Shpongle, Zavoloka, Banco de Gaia, Zingaia, Afro-Celt Sound System, early work by Yat-Kha (with Ivan Sokolovsky). Among the commercial acts which work with this subgenre, the following stand out: Praise, Enigma, Deep Forest, Ivan Kupala, Agricantus. The emphasis in this project is on the last group of artists, so modern aspects of Ethnic Electronica are studied.

The statistical results are extracted from analysis of songs that are previously filtered with seven octave-band filters. An octave band is frequency band where the highest frequency is twice the lowest frequency. The spectrum is split into seven octave bands with following centre frequencies: 125 Hz, 250 Hz, 500 Hz, 1 kHz, 2 kHz, 4 kHz and 8 kHz. The used bank of octave-band filters (IEC 1260 standard) is shown on Fig. 1.

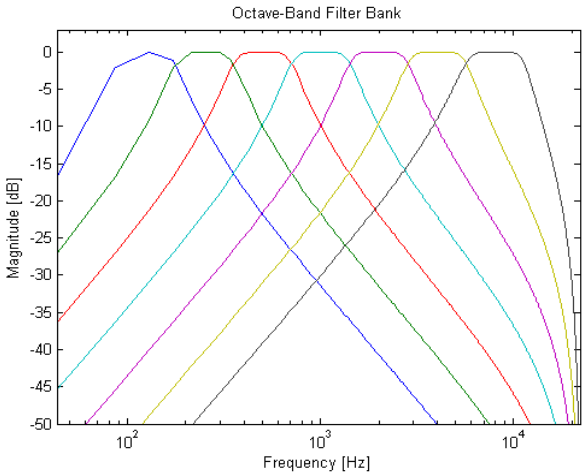

Figure 1. Octave-band filter bank

II. METHOD OF ANALYSIS

All songs are extracted from compact disks and converted to stereo wav audio format. Used wav format has following characteristics: sample frequency is 44.100 kHz and bit rate is 1411 kbps.

MATLAB code is generated for processing data and getting statistical properties. The used algorithm is shown on Fig. 2 [6].

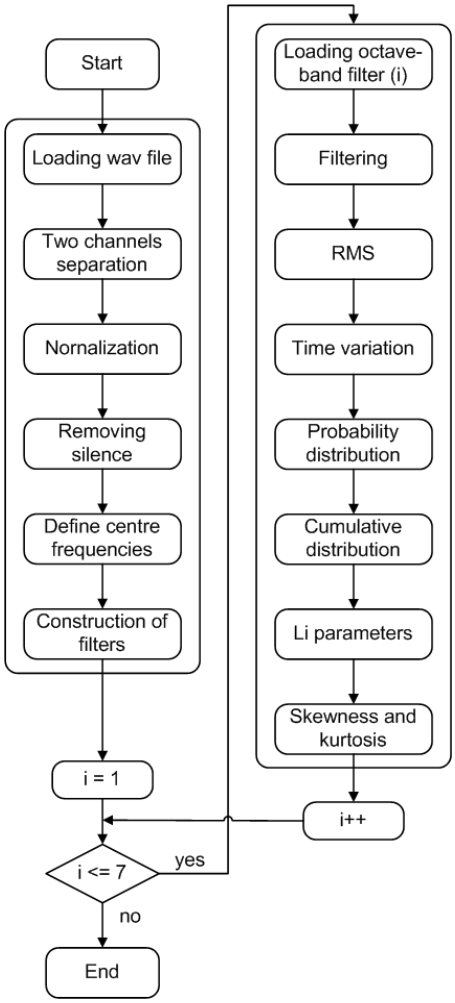

Figure 2. The used algorithm for signal processing

Method of analysis consists of several steps. Both channels of each song are considered as separated signals, so separation of channels is the first step. After data are gathered and statistical parameters are found, obtained values for two channels are averaged.

The second step is normalization of signals to 0 dBFS. The maximum sample of each song is set to 0 dBFS and that way the upper limit of signal dynamics in analyzed songs are set to be the same. The next step is removing the intervals of silence at the beginning and at the end of songs. The value used as the lower limit of musically useful signal or the threshold of silence is -80 dBFS.

The next steps include calculation of following statistical indicators for all songs in the database: effective value, time variation of the signal level performed with a 10 ms period of integration in rms calculation and with a 70% overlap, probability and cumulative distribution, numerical indicators of dynamic properties (values of level exceeded in 5%, 50% and 95% of time: L_5, L_{50} and L_{95}), descriptors of the shape of probability distribution (skewness and kurtosis) and musically relevant dynamic range for each octave.

III. RESULTS OF ANALYSIS

Results of analysis shown on figures below are related to the averaged values for musical genre Ethnic Electronica. Considering octave band properties are not explicitly presented in existing literature, the results are compared only to the results which author extracted from Jazz and Blues genre [7].

Fig. 3 shows distribution of effective values for each octave band in Ethnic Electronica.

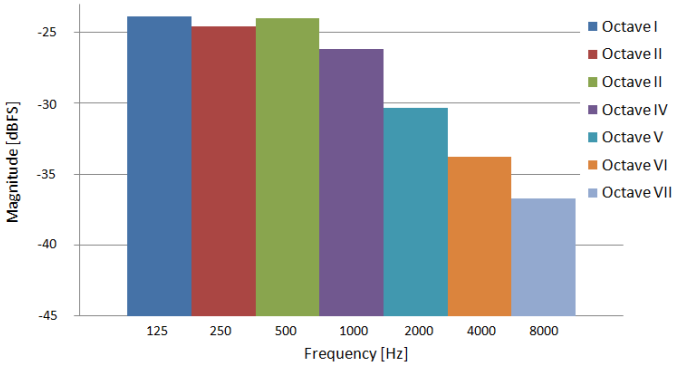

Figure 3. Efective values for each octave band

It can be seen that effective values are different from one octave band to another. The highest values are in the first three octave bands and after that values decrease monotonically. This characteristic can be used for designing an appropriate equalizer for analyzed musical genre.

Compared to the distribution for musical genre Jazz and Blues shown on Fig. 4, some differences can be observed. Major variations have been noticeable in the first and the last three octaves.

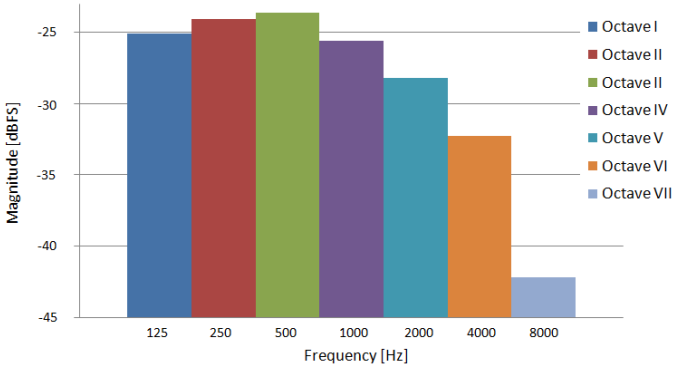

Figure 4. Efective values for each octave band for genre Jazz and Blues

Fig. 5 shows probability distribution for each octave band. All distributions are slightly titled to the right and have sharper peaks and longer, fatter tails around the mean compared to the Gaussian distribution. It will be proven by values that describe the shape of probability distribution below.

It is interesting that shape similar distributions are grouped. There are three such groups which are formed by the second and the third, the first and the fourth, the fifth, the sixth and the seventh octaves.

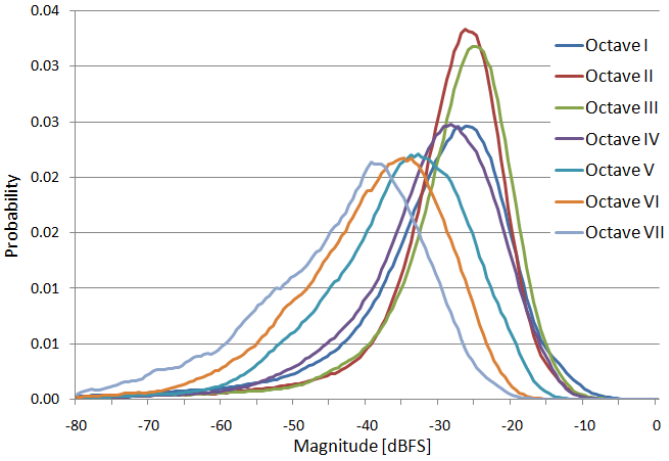

Figure 5. Probability distributions for each octave band

Descriptors of the shape of probability distribution are skewness and kurtosis. Skewness is a measure of the asymmetry of the probability distribution of a real-valued random variable [8]. Fig. 6 shows skew values obtained by the analysis that was carried out. It is shown that the values are quite uniform, so there are no significant differences between octave bands.

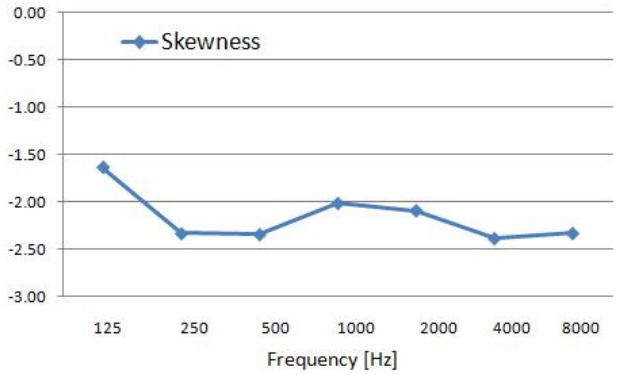

Figure 6. Skewness values for each octave band

In a similar way to the concept of skewness, kurtosis is a descriptor of the shape of a probability distribution. Kurtosis is a measure of peakedness of the probability distribution of a real-valued random variable [9]. Fig. 7 shows the values for kurtosis for seven octave bands. It can be noticed that the characteristic is monotonically increasing. It means the higher octave band the narrower the range where most of the signal level is positioned.

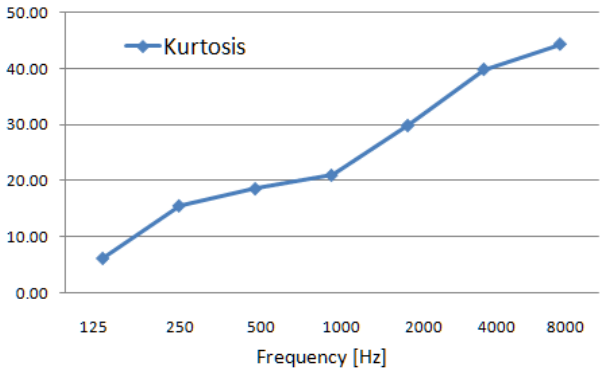

Figure 7. Kurtosis values for each octave band

Values for skewness and kurtosis obtained from Jazz and Blues genre are shown on Fig. 8 and Fig. 9. In both genres, skewness is negative and kurtosis is positive for each octave band, but absolute values are greater in case of Jazz and Blues. It indicates that, in comparison between these two genres, the probability distribution curves have shorter tails on the left side and lower, wider peaks around the mean in case of Ethnic Electronica.

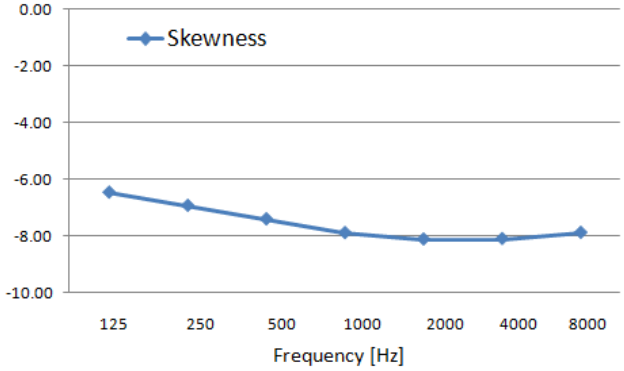

Figure 8. Skewness values for each octave band for genre Jazz and Blues

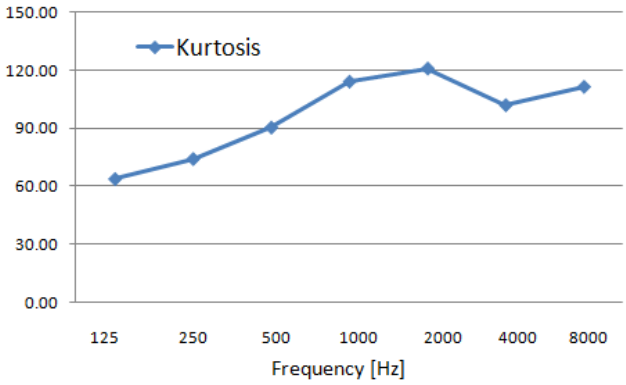

Figure 9. Kurtosis values for each octave band for genre Jazz and Blues

Variations in statistical distribution width around the maximum indicate the variation in a dynamic range which can be assumed as effectively used inside the limits of much wider musically relevant dynamic range. The diagram on Fig. 10 presents mutual relations between octave bands in that sense.

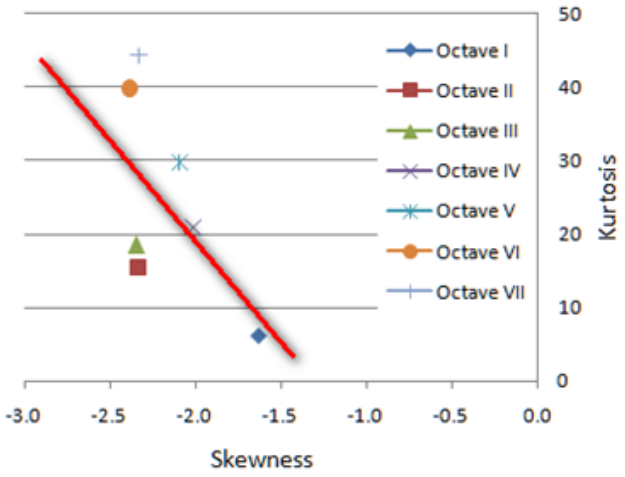

Figure 10. Relation between skewness and kurtosis

Position of an octave band on the diagram's left side means that it effectively occupies a narrower dynamic range. The position of an octave band toward the diagram's right side means the effective usage of the signal level is in a wider range. The diagram shows that the first octave effectively uses the widest dynamic range, while the second, the third, the sixth and the seventh octaves use the narrowest effective dynamic range.

Fig. 11 shows relation between skewness and kurtosis for genre Jazz and Blues. The first octave effectively uses the widest dynamic range as in Ethnic Electronica genre, but the fifth and the sixth octaves effectively use the narrowest effective dynamic range.

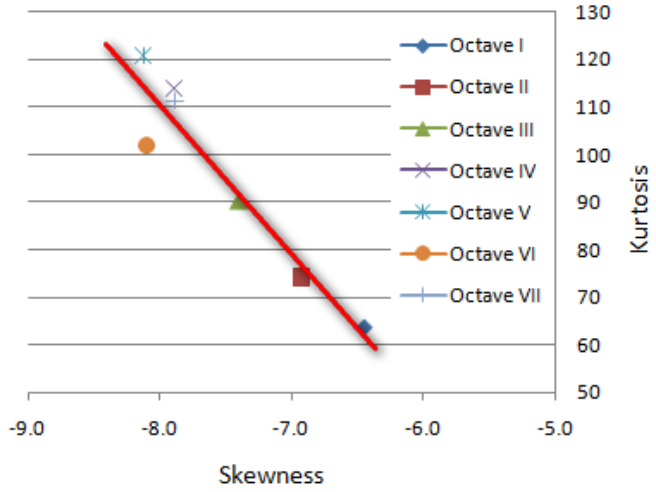

Figure 11. Relation between skewness and kurtosis for genre Jazz and Blues

Numerical indicators of dynamic properties, L_i parameters, are extracted from cumulative distributions. Fig. 12 shows these values for Ethnic Electronica genre, while Fig. 13 shows values for Jazz and Blues genre. It can be seen that numerical indicators in both genres are quite similar through all the octaves with no significant differences except for the first octave.

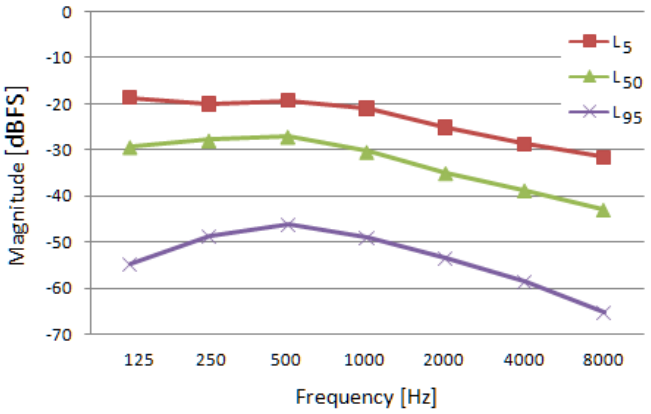

Figure 12. Numerical indivcators of dynamic properties

Parameter L_{95} can be observed as the musically relevant dynamic range. That is a value which the signal level exceeds in 95% of time in a musical piece. Fig. 12 shows dynamic ranges for each octave band (L_{95} series). It can be seen that musically relevant dynamic range is the narrowest in third octave band, while the widest is in the seventh octave band. Two other numerical indicators, L_5 and L_{50}, show similar behaviors, compared with L_{95}.

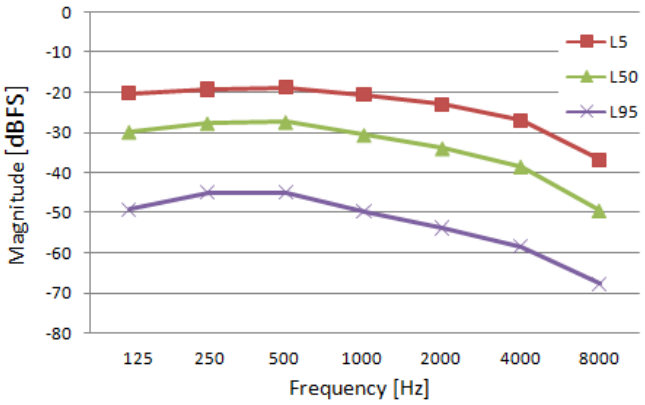

Figure 13. Numerical indivcators of dynamic properties for genre Jazz and Blues

IV. Conclusion

This paper presents dynamic properties of musical genre referred to as Ethnic Electronica. This genre is chosen because of missing of wider statistical approach to audio signal dynamics for genres that combine elements of electronic music and other musical styles. The signal database consists of more than three hours of musical pieces. Statistical data are analyzed inside seven octave bands. Statistical data extracted from Jazz and Blues genre are also presented for comparison purposes.

Obtained results show effective value, probability and cumulative distribution, numerical indicators of dynamic properties, descriptors of the shape of probability distribution and musically relevant dynamic range for each octave. These results could be used for several purposes such as extending the database of dynamic properties and designing the appropriate musical equalizer for analyzed musical genre.

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