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VOICE SIGNAL SYNTHESIS FOR CORRECTION OF HUMAN PSYCHOPHYSIOLOGICAL STATE

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Abstract
This work is devoted to the audio signal synthesis software package for the correction of human psychophysiological condition.
In order to ensure the synthesis of the sound effect of the required frequency, it is necessary to conduct a spectral analysis of the original bioelectrical signal, to determine the local extrema of the resulting spectral function, and to calculate the required frequency of the sound effect according to the obtained extrema. Synthesis of the spectral function and the sound effect of the desired frequency.

Keywords: Algorithm, synthesis, harmonic sound, Fourier transform, spectral analysis, spectrum extremes, multiple frequencies, software package.

Introduction

Dedicated to the software complex of voice signal synthesis to correct the psychophysiological state of a person. In order to ensure the synthesis of the sound effect of the required frequency, it is necessary to provide a spectral analysis of the original bioelectrical signal, to separate the local extremes of the received spectral function, to calculate the desired frequency of the sound effect according to the received extreme.

Under the influence of harmonic sound, the frequency is a multiple of the extremum frequency of the spectral function of the bioelectric signal received before the sound effect, where the multiplicity coefficient is $k = 2n$, synchronization, desynchronization or reconstruction of the bioelectric signal occurs, which helps medical personnel allows to correct the psychophysiological state of a person according to the established methodology. It is necessary to create a hardware and software complex to perform the synthesis of sound effects corresponding to the selected frequencies of the extreme frequencies of the spectral function.

This article is devoted to a software package for audio signal synthesis to correct the psychophysiological state of a person.

In order to ensure the synthesis of the sound effect of the required frequency, it is necessary to conduct a spectral analysis of the original bioelectrical signal, to determine the local extrema of the resulting spectral function, and to calculate the required frequency of the sound effect according to the obtained extrema. synthesizing the spectral function and the sound effect of the desired frequency.

Algorithmically, this problem is solved as follows:

The spectrum of the background bioelectrical signal is analyzed;

Local extremes are identified in the spectrum;

It is the required multiplicity factor to create a sound effect in the selected frequency range;

The sound effect is synthesized.

Below is a description of the blocks and algorithms of the software package for solving the listed subtasks.

Algorithm for calculating the spectral function, the spectral function is calculated for the time period T during which the bioelectrical signal was recorded. To determine the spectral function, the spectral decomposition interval is determined. T_sub is the minimum time for registering the bioelectrical signal, its value is determined based on the condition of ensuring the required number of pixels. The spectrum of the function by frequency $\Delta f : T_{sub} = \frac{1}{\Delta f}$

In order to reduce the influence of random noises such as artifacts, it is desirable to average the obtained spectral functions for a group of spectral decomposition intervals in the time interval T.

For each of the spectral decomposition intervals T_{subm} the spectral function is determined, then the average spectral function is calculated using the formula.

$\{SAS\}_P = \frac{1}{M}\sum_{I=0}^{M-1}\{SAS_I\}_P.$

In this algorithm, the number of intervals M is defined as the integer part of the partition T T_{sub} $M = \left[\frac{T}{T_{sub}}\right].$

The average spectral function is calculated according to the following algorithm:

Initial data for calculation:

- A digital bioelectrical signal has a sampling rate {X} F_d;
- duration T seconds or N=T*F_d

1.1 The measurement range is divided into sections of spectral decomposition {X_m} duration T_{sub} seconds will be on.

$N_{sub}= F_d*T_{sub}$ takes into account

$$m \in \left[0; \left[\frac{T}{T_{sub}}\right]\right] \quad \left[\frac{T}{T_{sub}}\right]$$

Here is the whole episode $\left[\frac{T}{T_{sub}}\right]$

1.2 Now we introduce the definition of the number of sections of the spectral decomposition.

$$M = \left[\frac{T}{T_{sub}}\right]. \quad \{X_m\}_P = \{X\}_{m*N_{sub}+P}. \quad P \in [0; N_{sub}), m \in [0; M)$$

Considering the ADC capacity of the electroencephalograph, B is equal to 8 bits, and the dynamic range D is equal to the signal {X}.

D=20*$log_{10}2^B$=B*20*$log_{10}2$=B*6.02=8*6.02=48.16 db

Therefore, a {W} Blackman mirror with a maximum sidelobe level of 58 dB was selected as the smoothing mirror.

1.3 For each spectral decomposition interval {X_m}, the weighting is performed using a Blackman window:

$\{X_m^w\}i = \{W\}_i * \{X_m\}i$ m ∈[0;M), i ∈ [0; N_{sub}),

{W}i=A_0-A_1*cos $\frac{2\pi i}{N_{sub-1}}$+A_2*cos $\frac{2*2\pi i}{N_{sub-1}}$

i ∈ [0; N_{sub}),

$A_0 = 0.42, A_1$=0.5, A_2=0.08.

1.4 Each window is for a weighted interval $\{X_m^w\}$ is the amplitude spectrum.

$\{AS_{m\ p}\}= | \frac{1}{N_{sub}} \sum_{i=0}^{N_{sub}-1} \{X_m^w\} i * e^{-j\left(\frac{2\pi}{N_{sub}}\right)pi}$

m ∈ [0;M), p ∈ [0; N_{sub}), j=$\sqrt{-1}$,

modulus of a complex number:

|c|=$\sqrt{c_{re}^2 + c_{im}^2}$,c∈C

1.5 modulus of a complex number: {ASm}

m ∈ [0;M), is the mean amplitude spectrum.

$\{SAS\}_p = \frac{1}{M} \sum_{m=0}^{M-1} \{AS_m\}p$ p∈ [0; N_{sub}).

The expanded formula takes the following form:

$\{SAS\}_p = \frac{1}{M} \sum_{m=0}^{M-1} | \frac{1}{N_{sub}} \sum_{i=0}^{N\ sub-1} \{W\}i * \{x\}_{m*Nsub+i}\} * e^{-j\left(\frac{2\pi}{N_{sub}}\right)pi}$

P ∈ [0; N_{sub}).

2. Algorithm for searching local multiple extrema

To search for local extrema of a discrete digital signal

{X}={$x_{i,}$i ∈ [0;N), N ∈ N}

quyidagi bosqichlar amalga oshiriladi:

2.1 The digital derivative of the signal is determined. {X} forward

{X} i=x_{i+1}-x_i, i ∈ [0;N-1)

after that

i ∈[1;N-1):

2.2 The countdown is considered to be a local maximum if the condition X_i is met.

$(\{x\}\underset{i=1}{\longrightarrow} > 0$ ^$\{X\}i < 0)$;

2.3 ix Count is a local minimum if the condition is met.

$(\{x\}\underset{i=1}{\longrightarrow} < 0$ ^$\{X\}i > 0)$;

2.4 The extrema are local multiples of each other . X_i va X_j if

$\frac{1x_i}{x_j}$ ∈Z, i≠ j.

Selecting the frequency of the sound harmonic effect according to the selected extremes in the given frequency range

For the set of extrema found

$\{X_E\}=\{ex_i, i \in [0;N_E), N_E \in N\}, N_E$

extreme and defined frequency range found.

$[f_{low}; f_{high}], f_{low}, f_{high} \in R, 0< f_{low} \leq f_{high}$

searches for multiple audio frequencies.

$f_j \in \{F_{kp}\},\{F_{kp}\}=\{f_{i,n}=ex_i)$

$f_j \in \{ F_{kp}\}, \{F_{kp}\}=\{f_{i,n}=ex_i*2^n, i \in [0; N_E), n \in Z, n \geq 0\}$

$f_j \in [f_{low}; f_{high}]$.

It is necessary to provide a slight deviation (turn) to solve the adaptation of bioelectric activity to a certain frequency. Frequency with respect to the given D. On the one hand, it allows you to adjust the phase of the effect, on the other hand, to compensate for the error in the calculation of the sound frequency.

4.Synthesis of sound harmonic effects according to selected parameters

For a frequency, the sound effects are synthesized at a sampling rate f. F_{ds}

T_s The effect has a harmonic form with a linear variable frequency corresponding to the deviations. The sound effect is as follows:

$\{S\}_i$=A*sin(2*π*$\{F_s\ \}i$*{x}i)

A- Amplitude

$i \in [0;N_s)$, $N_s = F_{ds} * T_s$

$\{F_s\ \}i=f-d+\frac{i*(f+d-(f-d))}{2*N_s}=f-d+\frac{i*d}{N_s}$

$\{x\}_i=i*\Delta x$

$*\Delta x=\frac{1}{f_{ds}}$

The sequence number of the sound buffer sample in this formula is related to time as follows:

$t \in [0; T_s]$,

$t \in [0; F_{ds} * T_s]$, $(\{X\}_i=i*\Delta x=\frac{i}{f_{ds}}) \in [0; T_s]$.

Next, the synthesized buffer is played back using an add-on to the OpenAL-based Opentoolkit software library.

Results:

Based on the proposed algorithm, a program for calculating several audio frequencies was developed based on the extreme frequencies of the bioelectric signal spectrum. The developed program is included in the hardware and software complex for audio correction of the psychophysiological state of a person.

References

1. Григорьева, Е. А. Певзнер, А. А. Шахназаров, С. С. Программа для анализа зависимости ЭЭГ от звуково-го воздействия [Текст] / Е. А.Григорьева, А. А.Певзнер, С. С. Шахназаров // Свидетельство о государственной регистрации программы для ЭВМ № 2010613540, в Реестре программ для ЭВМ 28.05.2010
2. Григорьева, Е. А. Певзнер, А. А. Шахназаров, С. С. Программа для определения моментов синхронизации и десинхронизации ЭЭГ / Е. А.Григорьева, А. А.Певзнер, С. С. Шахназаров // Свидетельство о государственной регистрации программы для ЭВМ № 2010615245, в Реестре программ для ЭВМ 13.08.2010
3. Оппенгейм, А., Шафер, Р. Цифровая обработка сигналов [Текст] / А. Оппенгейм, Р. Шафер. – М. : Техно-сфера, 2006. – 856 с.
4. Певзнер, А. А. Григорьева, Е. А. Закономерность реакции организма на звуковое воздействие [Текст] / А. А. Певзнер, Е. А. Григорьева // Оптико-электронные приборы и устройства в системах распознавания обра-зов, обработки изображений и символьной информации. Распознавание . Междунар. конф. : сб. материалов VIII. Ч. 2. – Курск, 2008. – С. 47–48.