Selection of the optimal compression method for cardio signals in the telemedicine

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***Abstract*— Several questions regarding compression of digital medical images with use of discrete wavelet -transformation are approached in order to find an optimal wavelet for compression of a cardiologcal signal. The criteria for choosing of a wavelet based of such indicators as scaling coefficient and signal error recovery is analyzed.**

An algorithm which scales the graphics of the initial wavelet and of wavelet signals comparing their characteristics has been developed in the MATLAB system

***Index Terms*— compression of digital medical images ,compression cardio, wavelet, choosing the optimal wavelet**

I. INTRODUCTION

The telemedicine is currently widely spread method of diagnostics and treatment at distance. Patient information in digital form, on the basis of which the doctor will make a diagnosis is transferred to another doctor via internet without any distortion.

Providing digital medical images via communication channels requires large amounts of data and sets high standards on the network equipment as wells as external storage capacities.

In order to achieve the required features of telemedical system, it’s necessary that the signal transmitted in the channel is processed according the respective algorithms, which will optimize the system as set by requirements. Typical operations of processing of a signal in telemedical systems are: compression of data, noise proof coding detection, filtration and estimation of parameters of signals.

As a consequence of this the actual challenge is to reduce the volume of data transmitted in digital systems using data compression, which will lower the requirements of the bandwidth of communication channel. This especially important for communication via telephone network.

Depending on the type of information needs to be transmitted, a different model of redundancy of input data has to be chosen. In addition, in each case, the compression of data transmitted will also have different objectives. There are various methods which are all optimized for specific tasks. Compression is based on elimination of redundancy contained in the original data. As an example, redundancy can be contained in the message as a repetition of identical symbol combinations or as a strong correlation between the individual parts of a message, etc.

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II. FORMULATION OF THE PROBLEM

The sampling of the cardiological signal leads to redundancy in the data. In order to reduce the redundancy the data has to be compressed. There are several methods of data compression, but all of them have the same basic principle, which is the volume reduction of initial data by selecting the smaller number of essential coordinates. Those coordinates can either be obtained by the transformation of a discrete signal or choosing them directly from initial data. Very often compression of data leads to the loss of information so the initial signal can't always restored precisely

The possibility of receiving effective compression of an electrocardiogram depends on the rate of high-frequency components of a signal which are present at the rather short fragments of a heart cycle. On those fragments of electrocardiogram the frequency of sampling is estimated on assumed errors of discrete representation. Therefore the low-frequency segments of a signal are redundant.

In order to eliminate the redundancy various methods of compression can be applied. This way many problems regarding storage, transmission and processing of an electrocardiogram can be solved.

Wavelets are widely used for solving problems of compression and processing of images. Wavelets are widely applied to the solution of problems of compression and processing of images.Compression of data on the basis of wavelet -transformation belongs to loosy data compression methods. Unlike JPEG which uses Fourier's transformation on a small area of the image, wavelet transforms an image as a whole. As a result compressed image has significantly less compression artifacts or noticeable distortions, especially at large scales of compression.

Most of medical signals have complicated time-and-frequency characteristics. As a rule, such signals consist of nearly simultaneous, short high-frequency components as well as similar long low-frequency components. As the signal of an electrocardiogram is a non-stationary one, it requires a specific approach for the choice of a suitable compression method.

Currently, the wavelet analysis is one of the most powerful and flexible means data research [2]. Application of wavelet transformation allows to complement the characteristics of the signals received by conventional statistical methods. The electrocardiographic signal is considered as one-dimensional signal that varies with time.

Discrete wavelet transform is currently widely used for the analysis and processing of ECG signals. With its help of it is possible to compress the ECG signal effectively, eliminating noise components, as well as to allocate the specific signal parameters (peaks, segments, intervals).

The wavelet transform of the one-dimensional signal consists of its splitting to the basis, which is built of wavelet with certain properties, by using scale changes and transfers.

Each of the functions of the basis characterizes a particular variable frequency and its localization in time:

$$s(t) = \sum_k C_k \psi_k(t)$$

where Ck - expansion coefficients that carry information about the signal, Ψk (t) - basis functions.

The function Ψ (t) with zero integral

$$\int_{-\infty}^{\infty} \psi(t)dt = 0$$

determines the signal components and generates itemized coefficient. Wavelets are classified by type and characteristics of the basic function Ψ_0 (t). Such as wavelet "Mexican hat» (MHAT-wavelet), the Haar wavelet, Daubechies wavelet, Morlet wavelet.

In order to evaluate the effectiveness of the compressed signal two indicators are used usually: compression ratio, defined as the ratio of the original signal samples to the number of received coordinates and signal reconstruction error. Absolute or mean squared error used commonly in that case.

As only orthogonal wavelets can be applied for the complete reconstruction of the signal and wavelet Haar is "nonsmooth", it's recommenede to use the Daubechies wavelets, estimated by iterative method . With an increase of the "smoothness" of the wavelet rises, which increases its capabilities. Daubechies Wavelets may not have symmetry, which narrows their use. In that case, symplets, derived from Daubechies wavelets, are used.

There are also wavelets, called coiflets. These wavelets proposed R.Coifman function of a wavelet Ψ (t) and wavelet generating function cp (t) have zero points. The presence of zero points in generating wavelet facilitates analysis and Wavelet transform. Coiflets are asymmetrical. But they are more symmetrical than wavelets.

III. THE SOLUTION OF THE PROBLEM

An algorithm which scales the graphics of the initial wavelet and of wavelet signals comparing their characteristics has been created and developed in the MATLAB system. According to the algorithm (Figure 1) length of the original signal and the length of the wavelet signal are the measured at first. The scale coefficients is determined afterwards

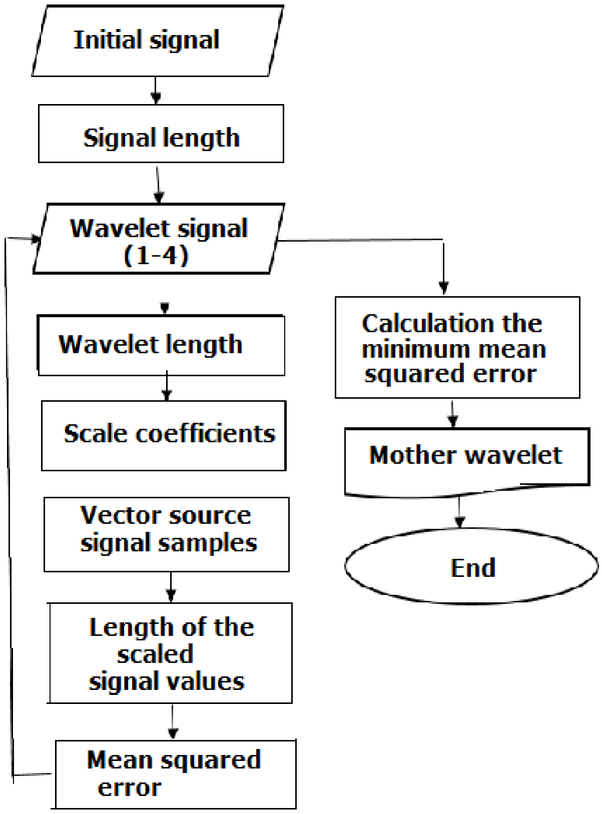

Figure 1: Algorithm for the selection of mother wavelet for the required medical signal

Thus, wavelet signal stretches to the level of the initial signal. The initial signal

is compared sequentially with wavelets "Mexican hat", Haar wavelet, Daubechies

wavelet and Morlet wavelet. Afterwards the mean squared error between the original signal and the above mentioned wavelets is being determined so a decision regarding selection of a mother wavelet among them can be made.

It was necessary to choose an optimal wavelet for compression of the the signal. Several cardio signals compressed Haar wavelets, Daubechies wavelets, simmlets and coiflets have been analysed. (Figutre 2)

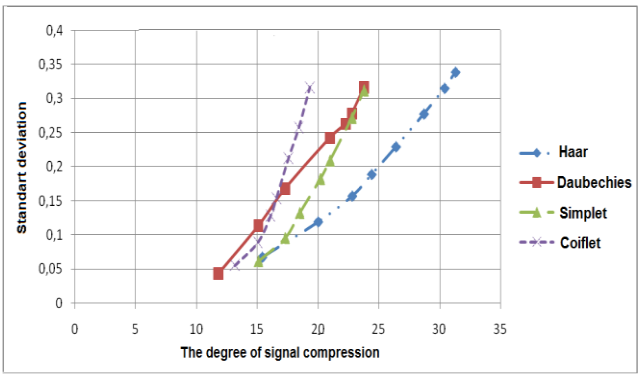

Figure 2. The dependence of the standard deviation on the degree of compression of cardio signals by wavelets

IV. CONCLUSIONS

Drawing conclusion from above table and corresponding chart, Haar wavelet is the most optimal compression wavelet for cardio signals. The respective algorithm determines a mother wavelet for cardio signals as well as other types of medical signals.

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