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Long-Term Simulation of Digestive Sound Signals by CEPSTRAL Technique

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Abstract**—**In this study, an investigation over digestive diseases has been done in which the sound acts as a detector medium. Pursue to the preprocessing the extracted signal in cepstrum domain is registered. After classification of digestive diseases, the system selects random samples based on their features and generates the interest nonstationary, long-term signals via inverse transform in cepstral domain which is presented in digital and sonic form as the output. This structure is updatable or on the other word, by receiving a new signal the corresponding disease classification is updated in the feature domain.

Keywords**—**Cepstrum, databank, digestive disease, acoustic signal.

I. Introduction

THE cepstrum transform is first used for feature extraction of gastrointestinal diseases. It is the then used to create a databank from nonstationary and variable signals of gastrointestinal diseases. The normal signals from three common diseases, namely Hernia, Adeno carcinoma and Gallstone illus will be processed and have its features extracted. Two feature vector are created for each of the four groups above are applied as input data to the second step, in the second step, our goal is to produce digestive signals. The program is then capable of providing digestive signals for several kinds of diseases, and can provide normal situation for every cycle. The prominent feature of these signals is that they are nonstationary.

This method provides the possibility of training people to recognize gastrointestinal diseases by listening to intestinal sounds as well as recognizing diseases from visual signal features and provide variable signal for systems recognition validation.

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II. Methods and Instrumentation

It is necessary to have a number of sample signals for each disease to obtain the appropriate result. To record gastrointestinal sounds, an electronic stethoscope (androscope) has been used and 12 sample signals for every disease have been recorded. The cepstrum algorithm has been used to analyze these samples.

III. Cepstrum

Using cepstrum coefficient is one of the best methods for processing acoustic signals and the appropriate software for this aim is MATLAB.The cepstrum of the signal is defined as the inverse Fourier transform of the logarithm of the magnitude of the Fourier transform of the data sequence, which can be written as:[1]- [2]-[3]

$$C_n=\text{idft}(\log|\text{dft}(x[n])|) \quad (1)$$

$$C_x[n]=\frac{1}{2\pi}\int_{-\pi}^{\pi}\ln|X(e^{j\omega})|e^{j\omega n}d\omega \quad (2)$$

The results of the cepstrum algorithm have two features:

1- Complex logarithm produces a new Fourier transform, the real part it is log| X (e^jw)| and the imaginary part is < X (e^jw). So we can calculate the Hilbert transform when the complex cepstrum is casual.

2- Complex cepstrum define a class of systems that it is linear filter and its composition with convolution is generalized in it.

IV. Feature Extraction

It is applied the cepstrum transform to each signal and 15 coefficients of this transform are used to form a vector. For each signal, so with 12 samples for each disease, it is created a matrix that is 12*15 in size. It is obtained a cluster for each disease with averaging columns in this matrix.[4]

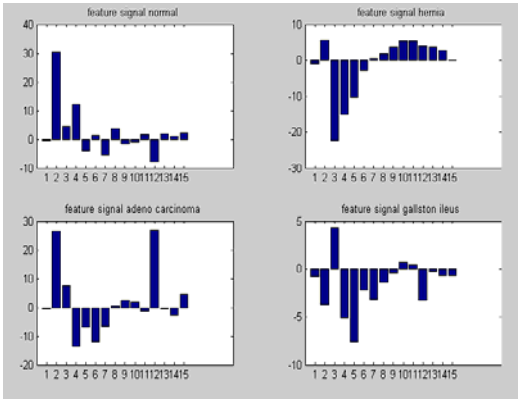


Fig. 1 Cepstrum coefficient as a feature for each class of diseases

The data distribution probability has been shown in Fig 2. The more linear the corresponding class is the higher normal distribution probability will be.

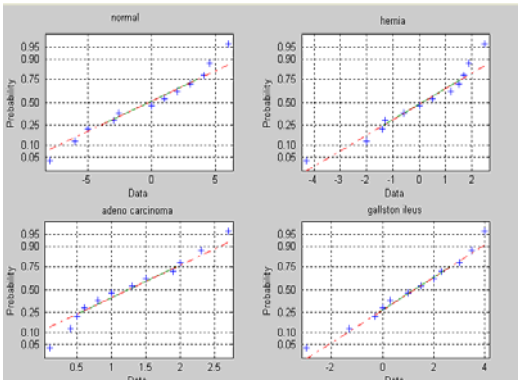


Fig. 2 The probability of distributed of one of the feature vector of characteristic for 4 groups to be normal

In the other method, it has been used cepstrum characteristic, so it has been extracted six curves from basic signal. [1].

1. At first, it has been taken cepstrum of each signal that include four types of sample signals such as diseases like Hernia, Adeno carcinoma, Gallstone illus and normal has been shown in Fig. 3.

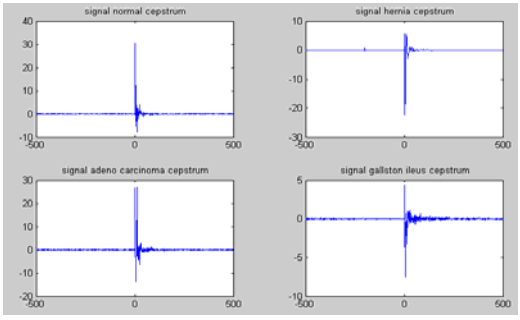


Fig. 3 Complex cepstra for sample signals

2. The signal was multiplied by an appropriate weighting factor, where a represents some constant Fig .4 shows the complex cepstra of the sample signals which have been weighted using a=0.76 for each signal.

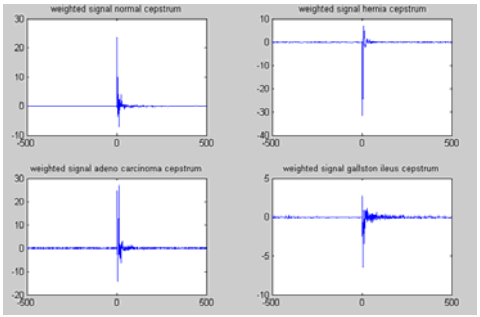


Fig. 4 Complex cepstra of the sample signals exponentially weighted with a=0.76

3.Fig. 5 shows the minimum and maximum phase components for the sample signals.

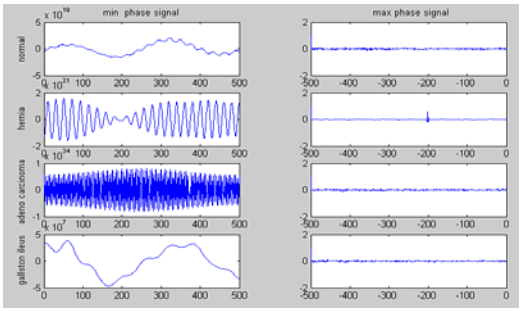
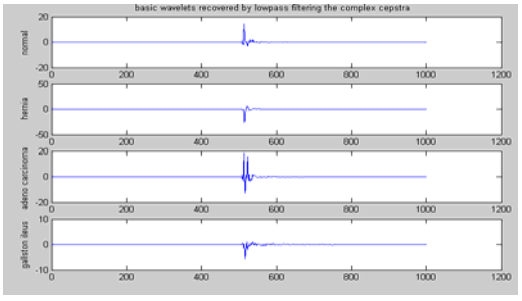


Fig. 5 Component signals

4.The complex cepstra recalculated on the basis of these weighting factors were low pass filtered using a window 20 samples in width and centered at the origin.(Fig. 6).



(1)

Fig. 6 Basic wavelets recovered by low pass filtering the complex cepstra with a window w=20 samples centered at the origin

5. Fig. 7 shows the excitation function reconstructed after high pass filtering of the complex cepstra showing in Fig. 4.

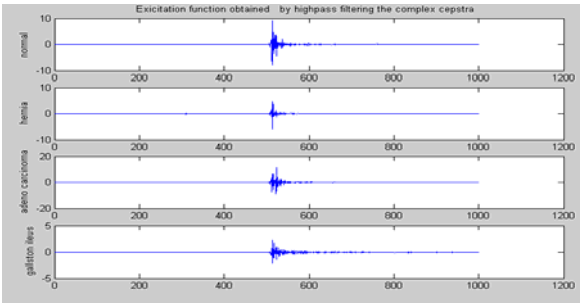


Fig. 7 Excitation function obtained by high pass filtering of the complex cepstra with a window w=20 samples

The mean and standard deviation of taken vectors are suitable variables for forming feature vector of signal. So for each signal we have 12 features and for each group 12 signals are selected. So we will have a matrix with 12*12 sizes, for each group. In fact to obtain feature vector for each group of this matrix, for each training signal feature the mean and standard deviation is obtained.

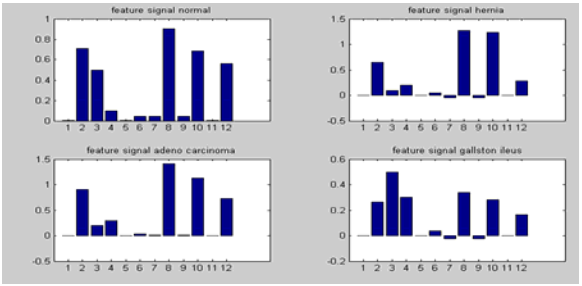


Fig. 8 Feature vector for each groups that is obtained from taken mean

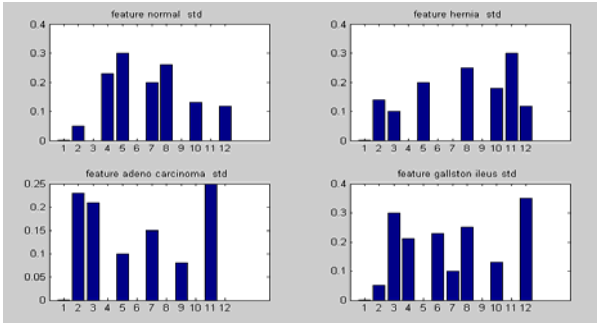


Fig. 9 Feature vector for each groups that it is obtained from taken standard deviation

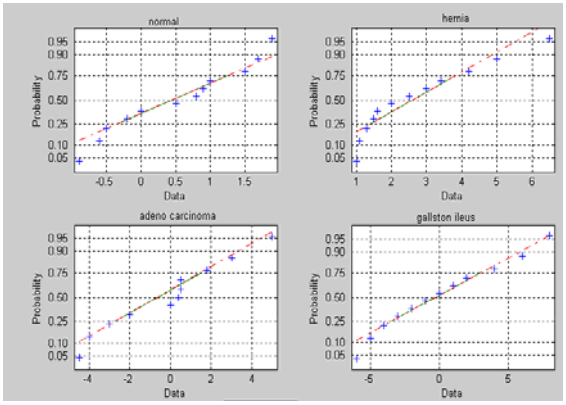


Fig. 10 The probability of distributed of one of feature vector of characteristic for 4 groups to be normal

V. Producing Nonstationary Signals

Two features vectors that related to each of these 4 groups is output of mentioned algorithm and this section is used as a input data. Each of these vectors has 12 characteristics. First feature is standard deviation.[5].We need cepstrum coefficient for producing nonstationary and long time signals before reconstruction , according to feature clusters of classes, cepstrum coefficient is produced by a series of new coefficient that is situated in the same group and its differ from other signals. Since, produced signals should be belonged to feature clusters of each group, characteristics of produced signal that have been obtained from the characteristics of the same group, is produced as its related to the same feature clusters so at first feature vectors is produced. To creation a feature vector, a random sample in a 12-dimentional space is used to make a cluster.

By using new characteristic, a sample from cepstrum coefficient that it was saved before, so that it is changed that mean and standard deviation become equal that they are obtained. So they are obtained new coefficient for creating one new signal.

By inverse transform cepstrum from coefficient , we could produce signal in time-domain, this action in each period from producing time have been done independent for creating nonstationary signal and correct time varying in longtime signal.

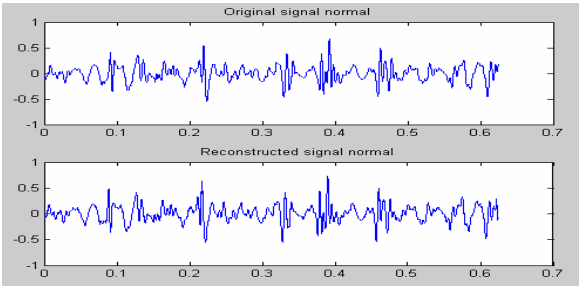


Fig. 11 Original normal signal and reconstruction signal

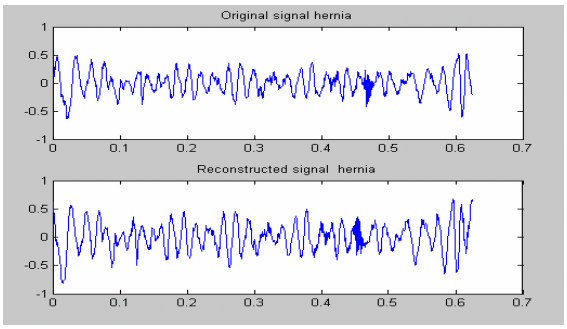


Fig. 12 Original hernia signal and reconstruction signal

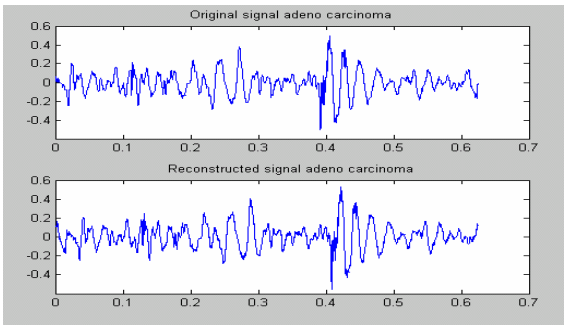


Fig. 13 Original Aden carcinoma signal and reconstruction signal

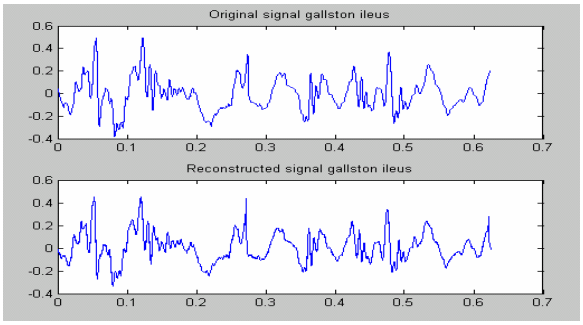


Fig. 14 Original gallstone illus signal and reconstruction signal

VI. Conclusion

The system validation can do by two methods such as signal processing and clinical. In first method, identify signals for testing have been given to system for doing this comparison; it has been used two algorithm.

First algorithm, in this method, Euclidian distance related to feature vector from each group (the mean of characteristic of signals from each groups) and feature vector that related to testing signal is measured. The shortest distance is standard of distinction for signal to belong to one of groups.

Second algorithm: in this method, difference between data and mean is calculated and result is divided to standard deviation.

If result is less than one then data belong to this group. If for more than one group result become less than one then this signal belong to a group that have a shortest result. Showing results in Table 1 to 4:

TABLE I
THE RESULTS WHEN FEATURE VECTOR IS OBTAINED BY USING CEPSTRUM COEFFICIENT AND USING COMPARISON ALGORITHM REALATED TO FIRST METHOD

group	[a] Accuracy percent
normal	75
Adeno carcinoma	72
Gallstone illus	68
Hernia	71

TABLE II
THE RESULTS WHEN FEATURE VECTOR IS OBTAINED BY USING CEPSTRUM COEFFICIENT AND USING COMPARISON ALGORITHM RELATED TO SECOND METHOD

group	[a] Accuracy percent
normal	78
Adeno carcinoma	75
Gallstone illus	72
Hernia	74

TABLE III
THE RESULT WHEN FEATURE VECTOR IS OBTAINED BY USING DIFFERENT CURVES AND USING FIRST METHOD ALGORITHM

group	[a] Accuracy percent
normal	89
Adeno carcinoma	85
Gallstone illus	80
Hernia	82

TABLE IV
THE RESULT WHEN FEATURE VECTOR IS OBTAINED BY USING DIFFERENT CURVES AND USING SECOND METHOD ALGORITHM

group	[a] Accuracy percent
normal	95
Adeno carcinoma	93
Gallstone illus	89
Hernia	91

As a results, second method for achieve feature vector is better than other methods, and the percentage of system accuracy is highest. In second processing method for system validation is used frequency spectrum. Figs 17, 18 and 19 in showing comparison between frequency spectrum of original signal and reconstruction signal.

Reconstruction signals have credibility because of high similarity in frequency domain. [6]

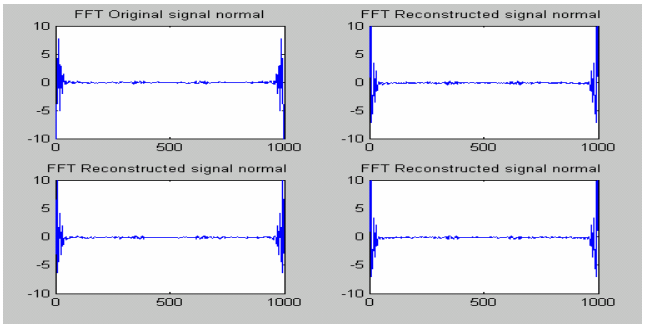


Fig. 15 FFT transform from normal signal and 3 samples of reconstruction of them

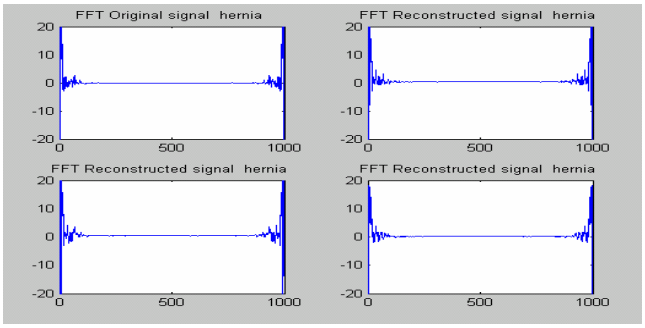


Fig. 16 FFT transform from hernia signal and 3 samples of reconstruction of them

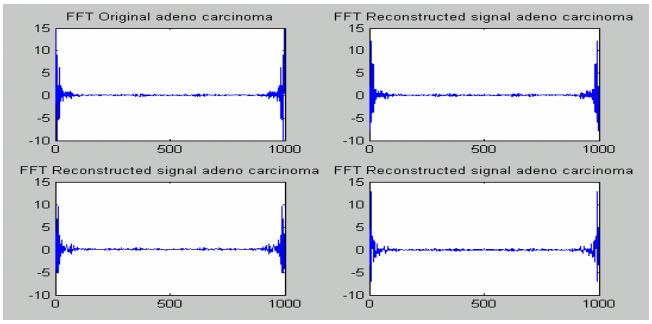


Fig. 17 FFT transform from Aden carcinoma signal and 3 samples of reconstruction of them

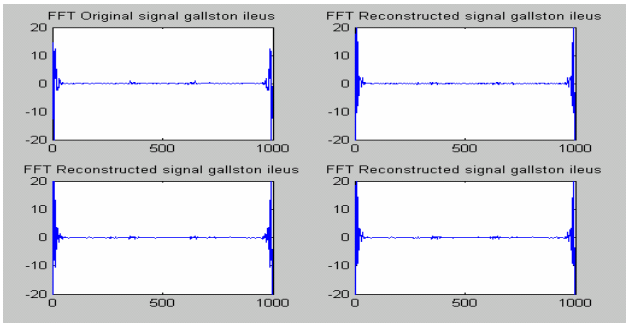


Fig. 18 FFT transform from gallstone illus signal and 3 samples of reconstruction of them

Other standard validation is MSE (mean square error), this standard have many application. If MSE is less then similarity of reconstruction signals and the accuracy of them are confirmed.

Also simulated signals are certified clinically by physicians.

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