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HTTP Compression for 1-D signal based on Multiresolution Analysis and Run length Encoding

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Abstract. In this paper, a method proposed for the HTTP compression of one dimensional (1-D) non-stationary nature of signal like speech and electrocardiogram signal. Here compression is achieved based on discrete wavelet transform decompositions at different levels (DWT) and run-length encoding (RLE). For the HTTP all process is done based on text analysis of wavelet coefficient, its prevent the signal information from unauthorized users. The performance of compression is analyzed by compression ratio (*CR*) and other fidelity parameters like signal-to-noise ratio (*SNR*) are shows the compressed/reconstructed signal properties.

Keywords: HTTP, Compression, DWT, RLE, TCP/IP.

1. Introduction

The HTTP is a hypertext transfer protocol on the World Wide Web (www); it's operated at application level in TCP/IP model. On the web HTTP compression is method to compress content transmitting from the host web server to client or requesting web browser [1]. It means HTTP compression response is compressed format of massage to client web browser from host server. The benefit of compression is saving the transfer data volume and increases the transmitting or receiving speed on web browser and takes minimum loading time of web pages [1-2]. In this paper, HTTP compressions applying for the 1-D non-stationary nature signal like speech and electrocardiograms (ECG) in form of text on the web. Here proposing a signal processing method using speech and ECG signals in form of text data based on the multiresolution analysis. Multiresolution analysis of signal is obtained by discrete wavelet transformation; its dividing the signal into the different resolution or sub-bands depends on the signal decomposition levels. The analysis provides the benefit in HTTP compression because DWT represent the signal in less significant number of coefficients as compare to original signal. In case of signal transmission on web using HTTP these wavelet coefficients transmitted as the text, for the further compression increase using the run-length encoding and encoded data are transmitted. At the client or receiver web page receive massage obtained using decoding and inverse transformation of received data. Fig.1 shows the network model for web application based on HTTP Compression System.

During the last decade, the Wavelet Transform, more particularly Discrete Wavelet Transform has emerged as powerful and robust tool for analyzing and extracting information from non-stationary signal such as speech and ECG signal due to the time varying nature of these signals. Non-stationary signals are characterized by numerous abrupt changes, transitory drifts, and trends. Wavelet has localization feature along with its time-frequency resolution properties which makes it suitable for analyzing non-stationary signals such as speech signals. Recently, many methods [3-10] have been developed based on wavelet or wavelet packets for compressing the speech and ECG signal. In this paper, proposed a method to compress the 1-D signal for the web communication using HTTP. This compression is achieved in form of text data using multiresolution analysis and RLE

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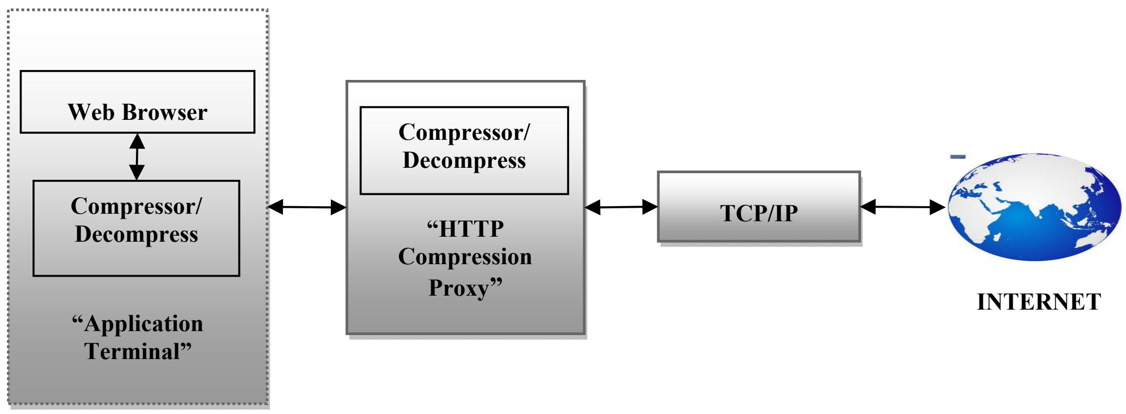

Fig. 1: Network model for web application based on HTTP Compression System

2. DWT and Multiresolution Analysis

The Discrete Wavelet transform (DWT) is a special case of WT that provide a compact representation of a signal in time and frequency [11-12]. Basic principal of wavelet transform is that it decompose the given signal in too many function by using property of translation and dilation of a single function called a mother wavelet, mother wavelet is defined as $\psi(t)$

$$\psi_{a,b}(t) = |a|^{\frac{-1}{2}} \psi\left(\frac{t-b}{a}\right) \tag{1}$$

Where, a is defines the dilation factor applied to the mother wavelet, and b is a translation factor.
Wavelet transform give the multiresolution decomposition of signal [12]. DWT decompose a signal at several n levels in different frequency bands. At each step of DWT decomposition, there are two outputs: scaling coefficients $x^{j+1}(n)$ and the wavelet coefficients $y^{j+1}(n)$. These coefficients are:

$$x^{j+1}(n) = \sum_{i=1}^{2n} h(2n-i) x^{j}(n) \tag{2}$$

and

$$y^{j+1}(n) = \sum_{i=1}^{2n} g(2n-i) x^{j}(n) \tag{3}$$

Where, the original signal is represented by $x^0(n)$ and j shows the scaling number. Here $g(n)$ and $h(n)$ represent the low pass and high pass filter, respectively. The output of scaling function is input of next level of decomposition, known as approximation coefficients as shown in Fig.2.

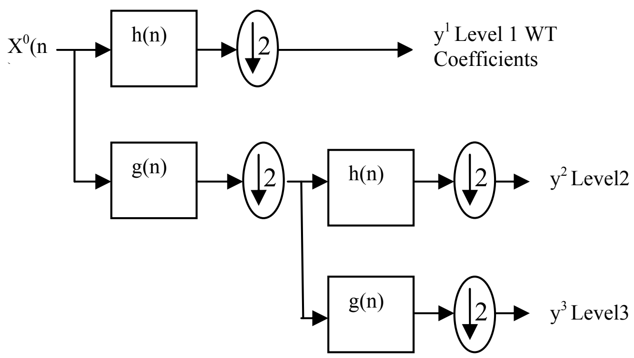

Fig.2: Filter bank representation of DWT decomposition

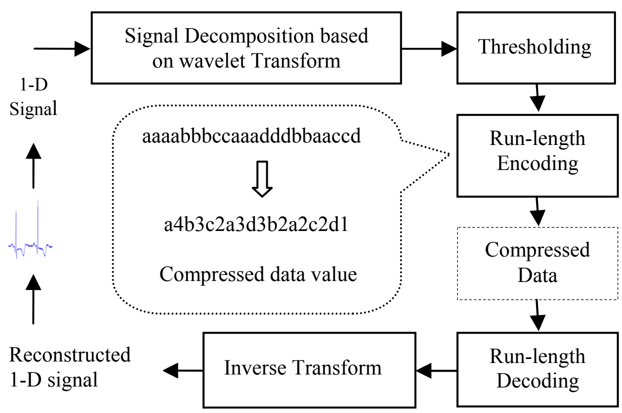

Fig. 3: Compression/ Decompression methodology based on wavelet transform and Run-length encoding

3. Methodology for signal compression

In this paper, the beta wavelet filters are used for the signal compression. For ECG compression, three most commonly used steps are DWT decomposition, thresholding and run-length encoding [12-15]. A compressed signal and its reconstructed signal form obtained from described methodology. A typical block diagram of the methodology is depicted in Fig. 3. Here, compression methodology illustrated in following three steps:

Step I. In this step, the mother wavelet is chosen, and then DWT decomposition is performed on the speech and ECG signal. Several different criteria can be used for selecting the optimal wavelet filter. For example, the optimal wavelet filter must minimize the reconstructed error variance and also maximize signal to noise ratio (*SNR*). In general, the mother wavelets are selected based on the energy conservation properties in the approximation part of the wavelet coefficients. Then, decomposition level for DWT is selected which usually depends on the type of signal being analyzed or some suitable such as entropy. Here, the beta wavelets are used as the mother wavelet and different decomposition level of DWT is applied on the ECG signal.

Step II. After computing the wavelet transform of the 1-D signal, compression involves truncating wavelet coefficients below a threshold which make a fixed percentage of coefficients equal to zero. Two different approaches are available for calculating thresholds. The first type is known as Global Thresholding which involves taking the wavelet decomposition of the signal and keeping the largest absolute value coefficients. In this, the threshold value is set manually, this value is chosen from DWT coefficient ($0\ldots x_{max}^{j}$), where x_{max}^{j} is the maximum value of coefficient. The second approach is known as Level thresholding in which the threshold value is calculated using Birge-Massart strategy [16] and is well suitable in case of signal compression. In this paper, level thresholding is applied at the different decomposition levels.

Step III. In this step, signal compression is further achieved by efficiently encoding the truncated small-valued coefficients. The resulting signal data contains same redundant data which is waste of space. In this paper, Run-length encoding applied on the redundant data for overcome the redundancy problem without any loss of signal data. Run length coding is a simple form of data compression in which runs of data are stored as a single data value and count, rather than as the original run [13-15]. From fig. 3 shown the RLE, how to encode data and give compressed signal data.

Finally, for the web communication the encoded compressed data are transmitted between the server and client.

4. Results and Discussion

In this section, a wavelet filter bank and RLE based methodology has been used for speech and ECG signal compression. Here, different wavelet filter bank used for the signal decomposition like Haar, Debauches and Coiflet wavelet. The performance of the wavelet filters in the field of speech and ECG signal compression can be evaluated by considering the fidelity of the reconstructed signal to the original signal. For this, following fidelity assessment parameters are considered:

- Compression ratio (*CR*):

$$\mathrm{CR} = \frac{\text{Number of significant Encoded wavelet coefficients}}{\text{Total number of coefficients}} \tag{4}$$

- Signal to noise ratio (SNR):

$$SNR = \left\{ \frac{\sum x^2(n)}{\sum |x(n) - y(n)|^2} \right\} \tag{5}$$

In the equations (5), $x(n)$ is the original1-D signal and $y(n)$ is the reconstructed signal. Table 1 illustrated the performance of methodology for the HTTP compression in form of text with the different wavelet transform and run-length encoding technique.

From Table 1 shown the compression and respective signal fidelity with the different wavelet filters, its illustrate that for speech signal db10 is give the higher signal compression as compared to other wavelet Haar and coif5. While, in case of ECG signal Haar wavelet give the better compression as compare to other both. On the other hand Coif5 is giving the better fidelity assessments for both signals. Figure (4) and (5) shows the performance of different wavelet at the different signal decomposition level for speech signal and ECG signal respectively.

Table 1 Performance of different wavelet with RLE

Signal	Wavelet Filter	No. of signal coefficient	No. of Encoded wavelet coefficient	CR	SNR
Speech signal "Hello"	Haar	16000	12537	21.64	60.16
Speech signal "Hello"	db10	16000	12365	22.71	62.79
Speech signal "Hello"	Coif5	16000	12389	22.56	62.87
MIT-BIH Rec. 100: M, 69	Haar	1014	884	12.82	41.13
MIT-BIH Rec. 100: M, 69	db10	1014	938	7.49	53.87
MIT-BIH Rec. 100: M, 69	Coif5	1014	953	6.02	68.90

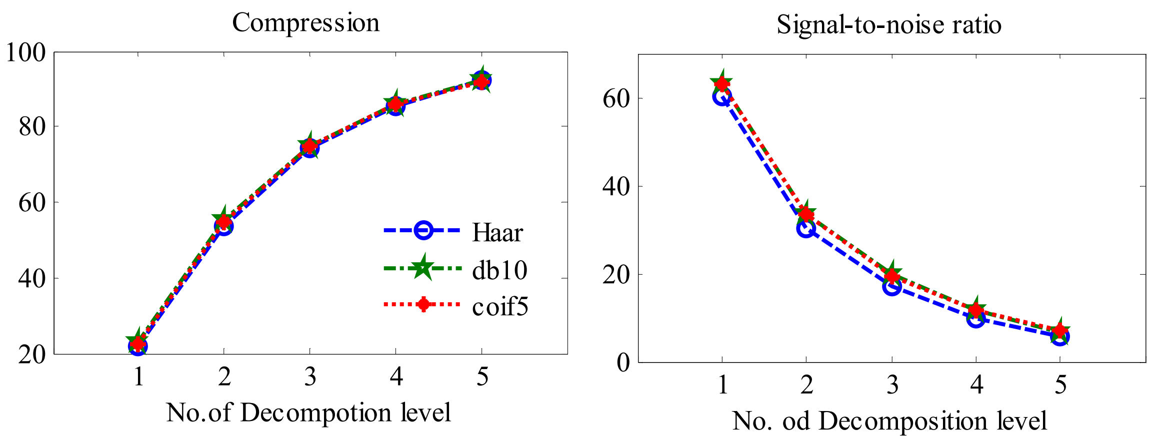

Fig. 4: Performance of different wavelet with five decomposition level for speech signal in term of *CR* and *SNR*

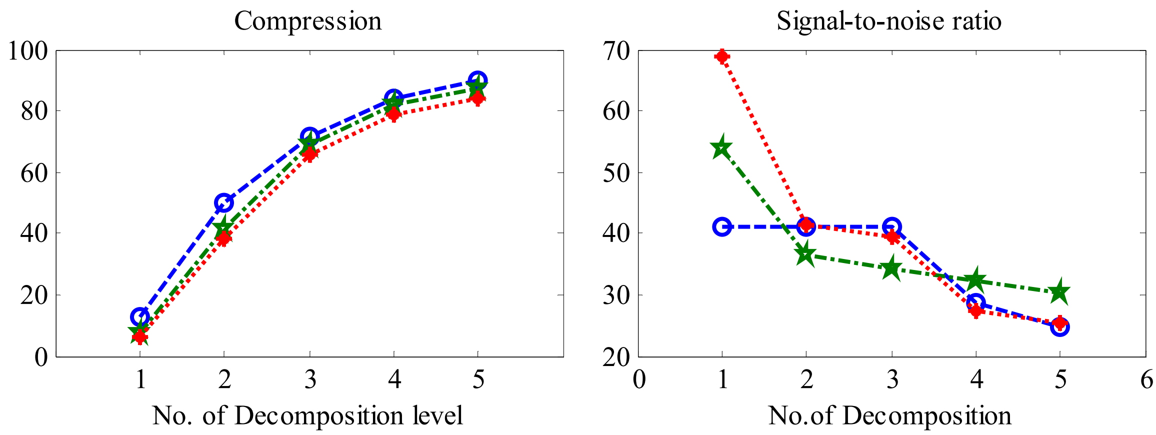

Fig. 5: Performance of different wavelet with five decomposition level for ECG signal in term of *CR* and *SNR*

5. Conclusion

In this paper, a one dimensional signal compression is described as a text format for the HTTP compression applications. The advantage of method is the compression performance is higher with low signal quality degradation at the single level decomposition. Other advantage of the method, its hidden all the information of signal at the transportation layer of TCP/IP layer and prevent to unauthorized clients because of transmitted data are encoded wavelet coefficients. The actual information is available when the client and server are compatible to described proposed HTTP compression algorithm. Hence the method is applicable for the 1-D signal compression for the HTTP uses with more security.

6. References

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