

A NOVEL APPROACH OF AUDIO WATERMARKING USING EMPIRICAL MODE DISINTEGRATION

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Abstract: *This paper contains a different treatment of watermarking methodology for enhancing sound waves and also for calculating focused strength and also to calculate the bias around Empirical mode Disintegration (EMD) is presented. For this a sound wave is marked into different segments called as casings and every casing is deteriorated adaptively by the process called observational or empirical mode disintegration(EMD), into characteristic oscillatory parts called Inborn Mode Capacities (Imfs). The sound wave will be processed into next stage for watermark and the synchronization codes are installed into the great of the last Intrinsic mode function (IMF), a low recurrence mode steady under diverse assaults and saving sound perceptual nature of the host signal. The information implanting rate of the proposed calculation is 46.9–50.3 b/s. depending on comprehensive reproductions, and next we can demonstrate the etymology of the concealed watermark for added substance turbulent, Mp3 packing, re-quantization, sifting, editing and inspecting. The correlation dissection demonstrates that our technique has preferred execution over watermarking plans reported as of last.*

Index terms: *Empirical mode decomposition (E.M.D),intrinsic mode function,audio watermarking*

I. INTRODUCTION

Now-a-days the procedure of computerized sound watermarking has gotten a lot of analysis and consideration in the writing to give effective answers for copyright assurance and security of advanced media by installing a watermark in the first sound sculpture. Principle prerequisites of advanced sound watermarking are vagueness, power and information limit. All the more correctly, the watermark must be imperceptible inside the host sound information to keep up sound quality and strong to flag twists connected to the host information by a vigour process. The proceedings of Sound watermarking must be not difficult to concentrate and make us

for demonstrate possession. To attain these necessities, looking for new watermarking plans is an exceptionally difficult issue by previous papers and references will diverse watermarking strategies of changing complexities have been proposed in different methods. On another paper conclusion for a powerful watermarking plan to distinctive assaults is proposed yet with a constrained transmission bit rate was discussed and slag with a undefined solution. To enhance the bit rate, watermarked plans performed in the wavelets area have been proposed. A breaking point of wavelet methodology is that the fundamental capacities are altered, and consequently they don't fundamentally match all true flag. To conquer this optimized solution, as of late bit rate, another sign decay system alluded to as Empirical Mode Decomposition (EMD) has been presented for examining non-stationary signs got or not from straight frameworks in completely versatile way. A significant preference of EMD depends on no from the earlier decision of channels or premise capacities. Contrasted with traditional bit based methodologies, EMD is completely information driven system that recursively breaks down any sign into a decreased number of zero-mean with symmetric envelopes AM-FM segments called Intrinsic Mode Functions (Imfs). By the usage of this sound watermarking innovation and expansion of audio signal is conceivable to install extra data in a sound track. To attain this, the sound sign of a music recording, an orally pre-recorded book or a business is marginally changed in a characterized way. This alteration is slight to the point that the human ear can't see an acoustic contrast. Sound watermarking innovation accordingly manages a chance to create duplicates of a recording which are seen by audience members as indistinguishable to the first yet which may contrast from each other on the premise of the inserted data. Just programming which encapsulates an understanding of the sort of inserting and implanting parameters is fit for concentrating such extra information that were installed awhile ago. Without such programming or if off base inserting parameters were chosen it is unrealistic to

get to these extra information. This averts unapproved extraction of implanted data and makes the procedure extremely dependable. This trademark is used by Music Trace in a focused on way. Each Music Trace client gets a special set of inserting parameters. Therefore, every client is just equipped for concentrating that data which he implanted himself. Getting to installed data of different clients, by difference, is not. The decomposition starts from finer scales to coarser ones. signal (n) is expanded by EMD follows

$$x(n) = \sum_{j=1}^c IMF_j(n) + r_c(n)$$

Where C is the quantity of Imfs $r_c(n)$ and signifies the last leftover. The Imfs are about orthogonal to one another, and all have almost zero means. The quantity of amazing is diminished when heading off starting with one mode then onto the next, and he entire disintegration is ensured to be finished with a limited number of modes. The Imfs are completely depicted by their neighbourhood amazing and therefore can be recouped utilizing these great Low recurrence parts, for example, higher request Imfs are sign ruled and in this manner their adjustment can prompt corruption of the sign. As come about, these modes can be thought to be great areas for watermark arrangement. Some preparatory results have seemed as of late in demonstrating the enthusiasm of EMD for sound watermarking.

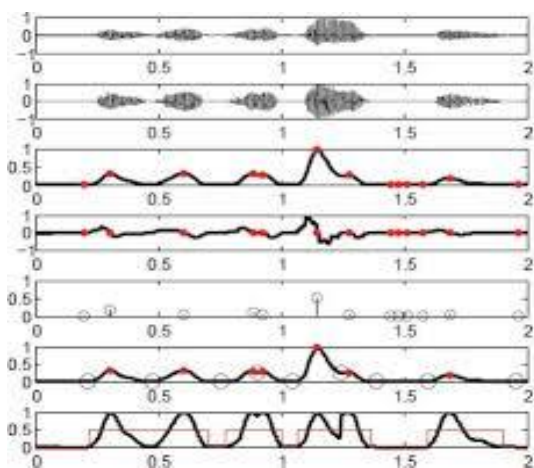


Fig 1. Decomposition of an audio frame by EMD

In previous references, it is Compared that watermarking of a sound signal with a enhance mode will be at the same time have better safety against assaults and intangibility, we implant the watermark in the compelling of the last IMF. Further, not at all like the plans presented in the proposed watermarking is just focused around EMD and without area change. We pick in our strategy a watermarking

method in the classification of Quantization Index Modulation (QIM) because of its great vigor and visually impaired nature.



Fig 2 Data Structure.

Attacks such as additive noise, MP3 compression, re-quantization, cropping and filtering. Our method has high data payload and performance against MP3 compression compared to audio watermarking approaches reported recently in the literature. The below block diagram illustrates the proposed watermark embedding process. The audio signal is divided into several fixed sized frames. In order to alter the DC component of a frame, the frame of an audio signal is processed using following steps;

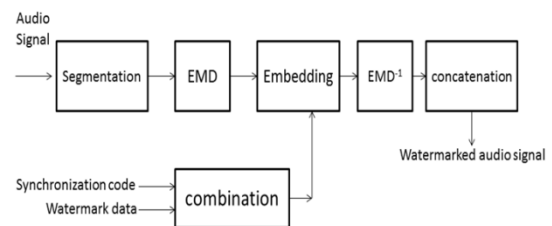


Fig 3 Watermark embedding

- 1) The Discrete Fourier Transform (DFT) is computed for each frame, $x[t]$. The first element of the vector thus computed represents the DC component of the frame.
- 2) The mean and power content of each frame is calculated as follows,

$$\text{Frame mean} = (1/N) \sum x[t]$$

$$\text{Frame power} = (1/N) \sum (x[t])^2$$
 Where N=Number of samples in each frame.
- 3) The first element of the frame vector obtained Through DFT is modified to represent watermark bit as described above with DC Bias Multiplier = 100.
- 4) The Inverse Discrete Fourier Transform (IDFT) of the frame vector gives the modified frame. These steps are performed until all the watermark bits are encoded.

II. PROPOSED METHOD

A. Proposed Watermarking Algorithm

The idea of the proposed watermarking method is to hide into the original audio signal a watermark together with a Synchronized Code (SC) in the time domain. The input signal

is first segmented into frames and EMD is conducted on every frame to extract the associated IMFs (Fig. 1). Then a binary data sequence consisted of SCs and informative watermark bits (Fig. 2) is embedded in the extreme of a set of consecutive last-IMFs. A bit (0 or 1) is inserted per extreme. Since the number of IMFs and then their number of great rely on upon the measure of information of each one edge, the quantity of bits to be installed changes from last-IMF of one casing to the accompanying. Watermark and Scs are not all installed in amazing of last IMF of one and only edge. As a rule the quantity of great for every last-IMF (one edge) is little contrasted with length of the parallel succession to be inserted. This likewise relies on upon the length of the casing. For information extraction, the watermarked sound sign is part into casings and EMD connected to each one casing (Fig. 4). Paired information arrangements are concentrated from each one last IMF via looking for Scs (Fig. 5). We demonstrate in Fig. 6 the last IMF prior and then afterward watermarking. This figure demonstrates that there is little contrast as far as amplitudes between the two modes. Truth be told, if the quantities of Imfs are diverse, there is no ensure that the last IMF dependably contains the watermark data to be concentrated. To defeat this issue, the filtering of the watermarked sign is compelled to concentrate the same number of Imfs as before watermarking. The proposed Watermarking plan is visually impaired, that is, the host sign is not needed for watermark extraction. Diagram of the proposed technique is definite as takes after

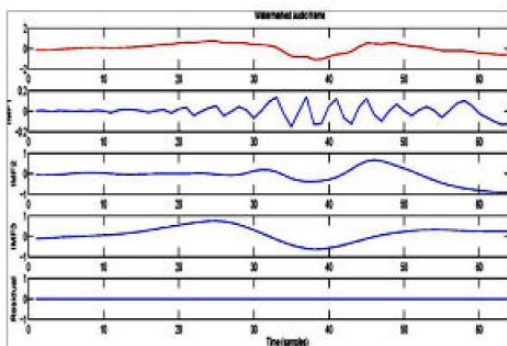


Fig.4. Decomposition of the watermarked audio framed by EMD.

B. Watermark Embedding

During production, copyright information in the form of a watermark can be anchored directly in the recording. This makes it possible to check at a later time whether a competitor, for example, has taken samples of music played on a valuable instrument and used them in his product without permission.

With the aid of the watermark, it is also possible to provide copyright verification in the event that a competitor claims he produced a given title. It can also be expedient to utilize audio watermarking of promotional recordings provided to radio stations or the press or when music tracks or audio books are sold by an Internet shop. Here the idea is to personalize every recording distributed. In such cases information is embedded as a watermark that can be used at a later time to monitor recipients. This can be the recipient's customer number, for example. If these recordings are found later on the Internet, the embedded data can be used to identify the person to whom the recorded material was originally distributed.

Basics of our watermark embedding are detailed as follows:

Step 1: Split original audio signal into frames.

Step 2: Decompose each frame into IMFs.

Step 3: Embed p times the binary sequence $\{m_i\}$ into extreme of the last IMF (IMF $_c$) by QIM [13]: where and are the extreme of the host audio signal and the watermarked signal respectively. Sign function denotes the floor function, and S denotes the embedding strength chosen to maintain the inaudibility constraint.

Step 4: Reconstruct the frame using modified and concatenate the watermarked frames to retrieve the watermarked signal.

C. Watermark Extraction

There are two ways that a privateer can vanquish a watermarking plan. The principal is to control the sound sign to make all watermarks imperceptible by any recuperation system. The second is to make a circumstance where the watermarking discovery calculation creates a false come about that is equivalent to the likelihood of a genuine result (Boney, et al., 1996). The location of the watermarking sign is the most imperative part of the whole watermarking methodology. For watermark extraction, host sign is splitted into casings and EMD is performed on every one as in installing. We extricate double information utilizing standard given by extraction. We then scan for Scs in the concentrated information. This technique is rehashed by moving the chose fragment (window) one specimen at time until a SC is found. With the position of SC decided, we can then concentrate the shrouded data bits, which take after the SC. Let indicate the twofold information to be concentrated and signify the first SC. To find the installed watermark we look the Scs in the succession a little bit at a time. The extraction is performed without utilizing the first sound sign. Fundamental steps included in the

watermarking extraction, demonstrated in Fig. 5, are given as takes after:

- Step 1: Split the watermarked signal into frames.
- Step 2: Decompose each frame into IMFs.
- Step 3: Embed p times the binary sequence {m_i} into extreme of the last IMF (IMFc) by QIM: where and are the extreme of the host audio signal and the watermarked signal respectively. sign function is equal, if is a maxima, and it is a minimal. Denotes the floor function, and S denotes the embedding strength chosen to maintain the inaudibility constraint.

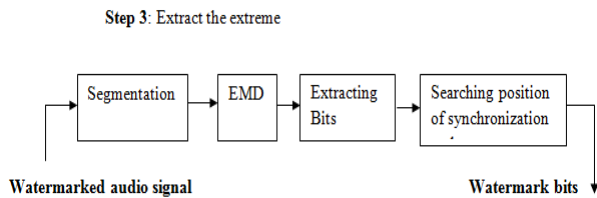


Fig.5. Watermark extraction

Step 4: Extract from using the following rule.

$$m_i^* = \begin{cases} 1 & \text{if } e_i^* - \lfloor e_i^*/S \rfloor \cdot S \geq \text{sgn}(S/2) \\ 0 & \text{if } e_i^* - \lfloor e_i^*/S \rfloor \cdot S < \text{sgn}(S/2) \end{cases}$$

Step 5: Set the start index of the extracted data, y of T=1 to and select L=N1samples (sliding window size). Step 6: Evaluate the similarity between the extracted segment V=y (I: L) and bit by bit. If the similarity value >_this, then is taken as the SC and go to Step 8. Otherwise proceed to the next step.

Step 7: Increase I by 1 and slide the window to the next L=N1 samples and repeat step 6.

Step 8: Evaluate the similarity between the second extracted segment, V=y (I+N1+N2: I+2N1+N2) and U bit by bit.

Step 9: I= I+N1+N2, of the new I values equal to sequence length of bits, go to Step 10 else repeat Step 7. Step 10: Extract the watermarks' and make comparison bit by bit between these marks, for correction, and finally extract the desired watermark Watermarking embedding and extraction processes are summarized in Fig. 7.

IV. PERFORMANCE ANALYSIS

We evaluate the performance of our method in terms of data payload, error probability of SC, Signal to Noise Ratio (SNR) between original and the watermarked audio signals, Bit Error Rate and Normalized cross-Correlation.

According to International Federation of the Photographic Industry (IFPI) recommendations, a watermark audio signal should maintain more than 20 dB SNR. To evaluate the watermark detection accuracy after attacks

$$BER(W, W') = \frac{\sum_{i=1}^M \sum_{j=1}^N W(i, j) \oplus W'(i, j)}{M \times N}$$

Where \oplus is the XOR operator and M*N are the binary watermark image sizes. And are the original and the recovered watermark respectively. Is used to evaluate the watermark detection accuracy after signal processing operations. To evaluate the similarity between the original watermark and the extracted one we use the measure defined as follows

Empirical Mode Decomposition

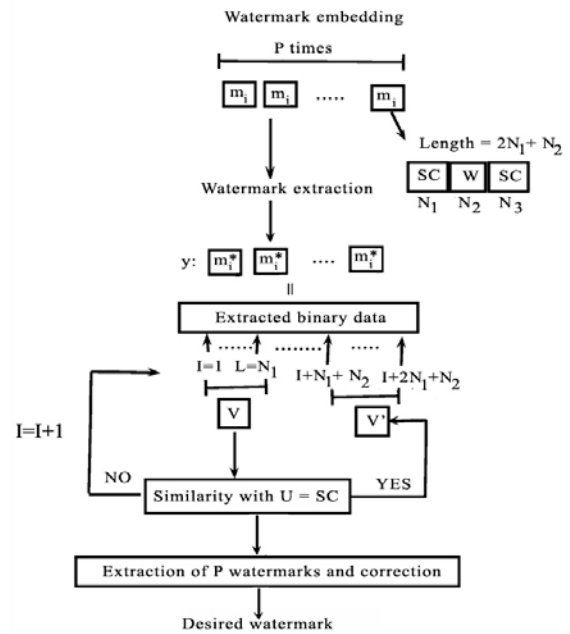


Fig.6 Embedding and extraction processes



Fig.7 Binary watermark

During the last decade, wavelet-based techniques (and variations) have proved remarkably effective for representing and analysing various stochastic processes, and especially those with scaling properties. Amongst a number of reasons for this success stands first the adequacy between the multi

scale nature of such processes and the built-in multi scale structure of wavelet decompositions, as well as companion benefits in terms of stationarization and reduced correlation. More recently, an apparently unrelated technique, referred to as Empirical Mode Decomposition (EMD), has been pioneered by Huang et al for adaptively representing functions as sums of zero-mean components with symmetric envelopes. Such decomposition is based on an idea of locally extracting fine scale fluctuations in a signal and iterating the procedure on the (locally lower scale) residual.

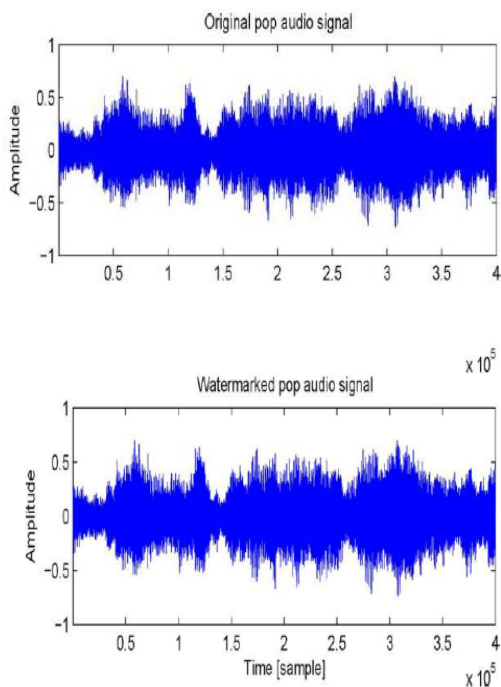


Fig.8 A portion of the pop audio signal and its watermarked version

Table 1 SNR and ODG comparison between original and watermarked audio

Audio File	SNR (dB)	ODG
Classic	25.67	-0.5
jazz	26.38	-0.4
Pop	24.12	-0.6
Rock	25.49	-0.5

As such, EMD corresponds in some sense to hierarchical multi scale decomposition but, in contrast with wavelet techniques. Nevertheless, it has been shown that, when applied to broadband processes such as fractional Gaussian noise or fractional Brownian motion, EMD behaves spontaneously as a dyadic filter bank resembling those involved in wavelet decompositions.

We will here report on our findings in this direction and compare EMD with wavelet-based techniques in terms of decorrelation properties,

IV. RESULTS

To demonstrate the adequacy of our plan, recreations are performed on sound signs including pop, jazz, rock and excellent inspected at 44.1 kHz. The inserted watermark, W, is a paired logo picture of size bits. We change over this 2d twofold $M \times n = 43 \times 48 = 1632$ picture into 1d succession keeping in mind the end goal to implant it into the sound sign. The C utilized is a 16 bit Barker succession 1111100110101110. Every sound sign is separated into casings of size 64 specimens and the edge is situated to 4. The worth is altered to 0.98. These parameters have been decided to have a decent trade off between vagueness of the watermarked sign, payload and strength. Fig. 9 demonstrates a parcel of the pop flag and its watermarked form. This figure demonstrates that the watermarked sign is outwardly unclear from the first one. Perceptual quality appraisal can be performed utilizing subjective listening tests by human acoustic discernment or utilizing destination assessment tests by measuring the SNR and Objective Difference Grade (ODG). In this work we utilize the second approach. ODG and SNR estimations of the four watermarked signs are accounted for in Table I. The SNR qualities are over 20 db demonstrating the great decision of worth and affirming to IFPI standard. All ODG estimations of the watermarked sound signs are between and 0 which exhibits their great qualities

A. Robustness Test

To assess the robustness of our approach, different attacks are performed:

--**Noise:** White Gaussian Noise (WGN) is added to the watermarked signal until the resulting signal has an SNR of 20 dB.

—**Filtering:** Filter the watermarked audio signal using Wiener filter.

—**Cropping:** Segments of 512 samples are removed from the watermarked signal at thirteen positions and subsequently replaced by segments of the watermarked signal contaminated with WGN

—**Resampling:** The watermarked signal, originally sampled at 44.1 kHz, is re-sampled at 22.05 Hz and restored back by sampling again at 44.1 kHz.

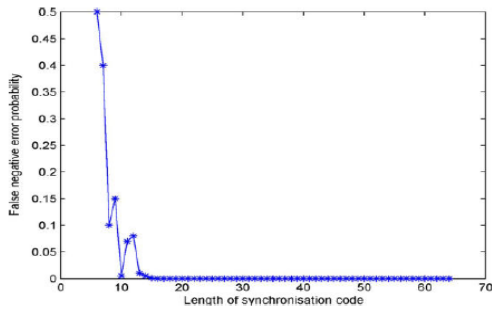


Fig.9 P_{fpe} versus synchronization code length

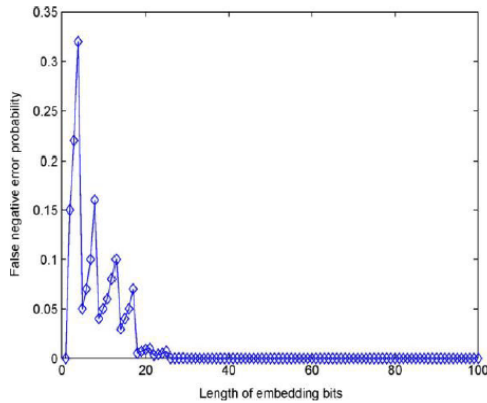










Fig.10 P_{fne} versus the length of embedding bits.

—**Compression:** (64 kb/s and 32 kb/s) Using MP3, the watermarked signal is compressed and then decompressed.

—**Requantization:** The watermarked signal is requantized down to 8 bits/sample and then back to 16 bits/sample. Table II shows the extracted watermarks with the associated values for different attacks on pop audio signal. Values are all above 0.9482 and most values are all below 3%. The extracted watermark is visually similar to the original watermark. These results show the robustness of watermarking method for pop audio signal. Even in the case of WGN attack with SNR of 20 dB, our approach does not detect any error. This is mainly due to the insertion of the watermark into extreme. In fact low frequency sub band has high robustness against noise addition.

TABLE II
BER AND NC Of Extracted Watermark For Pop Audio Signal By Proposed Approach

Attack type	BER %	NC	Extracted watermark
No attack	0	1	
AWGN (20 dB)	0	1	
Filtering	6	0.9482	
Cropping	0	1	
Resampling	3	0.9783	
MP3 (64 Kb/s)	0	0.9996	
MP3 (32 Kb/s)	1	0.9876	
Requantization	0	1	

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