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Comparative Analysis of Fourier Series& Empirical Mode Decomposition (EMD) for Adaptive Signal Processing

Kashif Ahmad
Department of Electrical Engineering, University of Engineering & Technology Peshawar, PAKISTAN.
Corresponding Author: kashifahmad2052@gmail.com.

ABSTRACT:

There are two of the most important mathematical findings and theoretical developments of recent decades have been the Fourier Transform and Fourier series since they straddle several pure mathematical, financial and physical sciences in their application. A simple yet elegant solution and its capacität for explaining a wide range of systems can be seen in the popularity of the Fourier series and FT. This research examines the possibilities of EMD as a technique for voice and audio processing. These signal extension into IMFs is adaptive and requires no preliminary assumptions regarding the signal to be investigated (stationarity and linearity). EMD features such as dyadic filter bank structures, IMF quasymmetry and an extreme overview of the IMF are employed as denoising, watermarking and coding. These contributions are illustrated by genuine and synthetic data, which reveal higher performance of EMD-based signal processing compared to widely known techniques such as the MMSE filter, the wavelet approach and AAC and MP3codecs. These results indicate the real potential of EMD in audio and speech processing as an analytical tool (adaptive). Despite the fact that the tools are displayed in 1D signals, applications and image processing in disciplines such as satellite imaging and biomedicine can be extended simply.

Keywords: Empirical Mode Decomposition, Fourier Series, Fourier Transform, EMD Signals.

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I. INTRODUCTION

A Fourier series refers to an infinite number of cosines and sines that expand regularly (x) [1,2]. In the Fourier series the orthogonal relations between cosines and sines are employed [3]. The harmonic analysis consists of studying the Fourier series and computing which is very helpful when dividing a periodic function to a series of simple terms that could be connected, recombined and resolved to detect the possible solution or an approximation to the original trouble in any accuracy practical or desired [4]. The examples above show how to use Fourier series to make successive approximations to common functions.

EMD is a method of signal decomposition which does not require a temporal domain to be left. It can be differenciated to other methods of analysis i.e., Wavelet decomposition and Fourier transform. The method is advantageous for evaluation of non-stationary signals and also for non-linear. This contrasts from the hypotheses driving our attempts thus far [5]. EMD is used to filter out functions which comprise an entire, almost orthogonal basis for the original signal [6]. The technique of the EMD determines completeness; it requires completeness in its deconstruction [6]. Thus, intrinsic mode function (IMF), despite not necessarily orthogonal, is sufficient to represent the signal.

II. METHODOLOGY

Fourier Series

Since their applicability covers several pure mathematical, financial, physical, and sciences. The Fourier Transform (FT) and Fourier series are two of the most theoretical developments and important mathematical discoveries of the previous few decades. The Fourier series and FT's fame can be traced back to a basic yet elegant solution that can describe a wide range of systems [7].The Fourier series is defined in equation (1).

$$f(x) = \frac{1}{2}a_0 + \sum_{n=1}^{\propto}(a_n \cos(nx) + b_n \sin(nx)) \qquad (1)$$

where in equation (1) the coefficients a_n and b_n are

$$a_n = \frac{1}{\pi}\int_{-\pi}^{\pi} f(x)\cos(nx)\,dx \quad (2a)$$
$$b_n = \frac{1}{\pi}\int_{-\pi}^{\pi} f(x)\sin(nx)\,dx \quad (2b)$$

Fourier Transforms are extensively used in signal processing to study the signals frequency structure. Whether the signal is seismic in origin, audio (i.e, X-rays, light, or radar), or electromagnetic, the Fourier Transform decomposes it into its component frequencies. Fourier Transformations are used in structural analysis to examine the harmonic structure of buildings and ports under various situations of soil motion and wind. These studies are utilized in signal processing to reduce noise and improve signal quality.

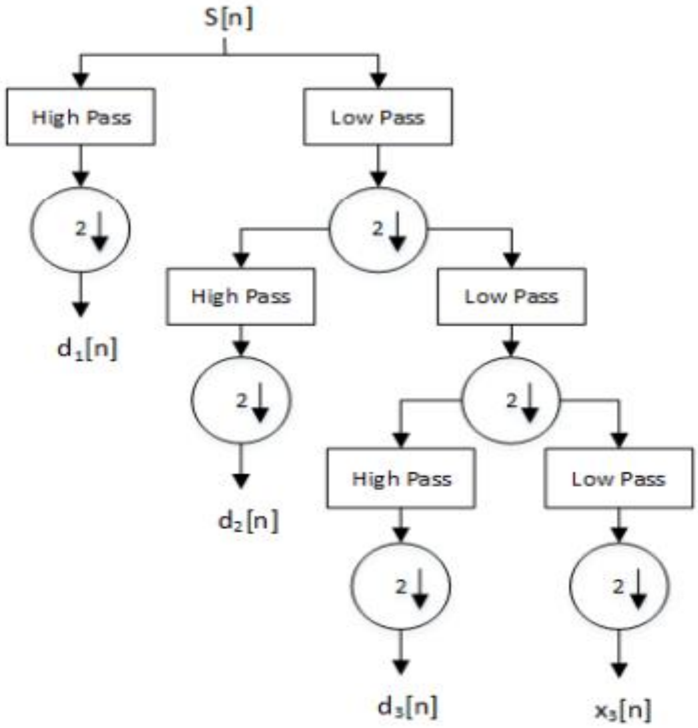

Fig 1: In the Mallet Decomposition Tree, the discrete-wavelet transformation steps are outlined. The outputs are sampled by 2, and the high-pass side output is completed, while the low-pass side is managed over again.

Empirical Mode Decomposition

It is the latest processing method (EMD). N.E. Huang has developed the adaptive signal treatment method EMD, which breaks down signal into a limited number of residual function and IMF [8]. In contrast to the Wavelet and Fourier transforms, the adaptive character of the EMD method enables the evaluation of both non-stationary and non-linear signals, which makes it easier to understand the original signal [8]. EMD can characterize tiny variations in time frequency that cannot be analyzed using Fourier. EMD creates IMFs that are easily compiled via a filtering procedure and with well-preserved Hilbert transformations. Each IMF describes the properties of not the whole signal but the local signal. The residue total and IMFs equates the original signal without any distortion or loss [9].

EMD produces an Hilbert spectrum, or energy-time-frequency distribution, like the Wavelet transform. However, there are a few fundamental distinctions between EMD, and the Wavelet transform that improve analysis.
1. Resolution of frequency-time is not constant
2. EMD does not function on the wavelet scale but on the distance scale between the extreme and extreme signal
3. No prior knowledge is required for EMD

4. The IMF is not a set of trigonometric functions

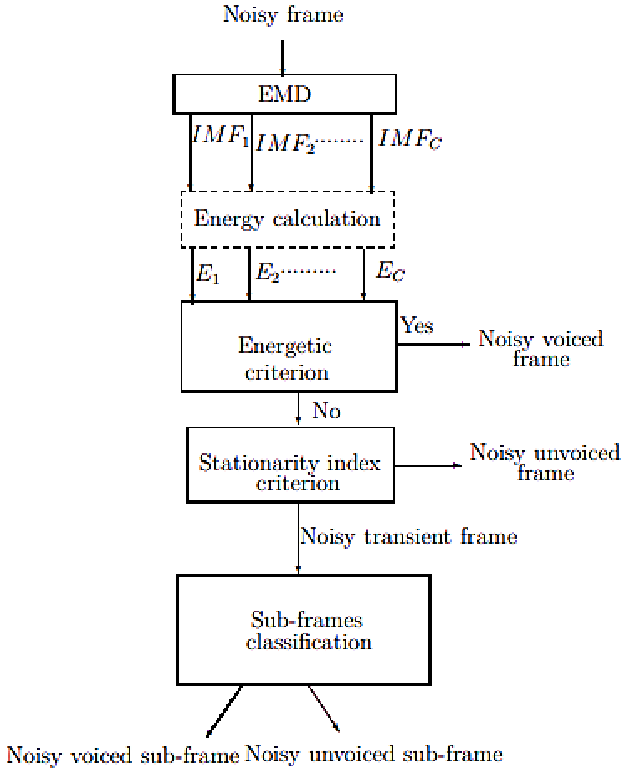

Fig2: Frame's classification scheme.

III. RESULTS AND DISCUSSION

When the amplitude alternates between defined lowest and maximum values at a constant frequency, the result is a non-sinusoidal periodic waveform called a square wave. The minimum and maximum values of a square wave are instantaneous in an ideal world. There are no restrictions on the duration or amplitude of the square wave because it is a particular instance of the pulse wave. The duty cycle of a pulse wave is the ratio of the high period to the entire period of a pulse wave. 50 percent of the time, a real square wave is generated (equal high and low periods).

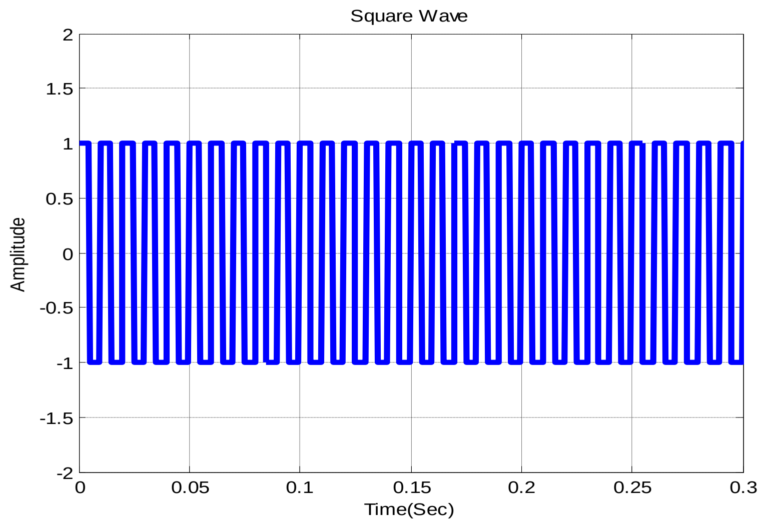

Fig 3: Square Wave

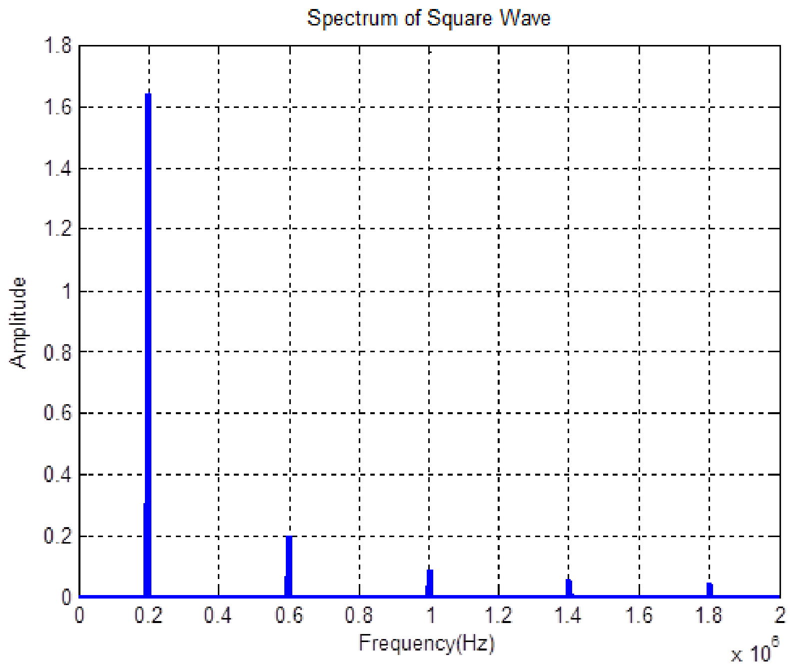

Fig 4: Spectrum of Square Wave

The results from Fourier series shows that the amplitude of frequency is maximum at 0.2 second time. And decreased time to time. The signal can be seen as digital.

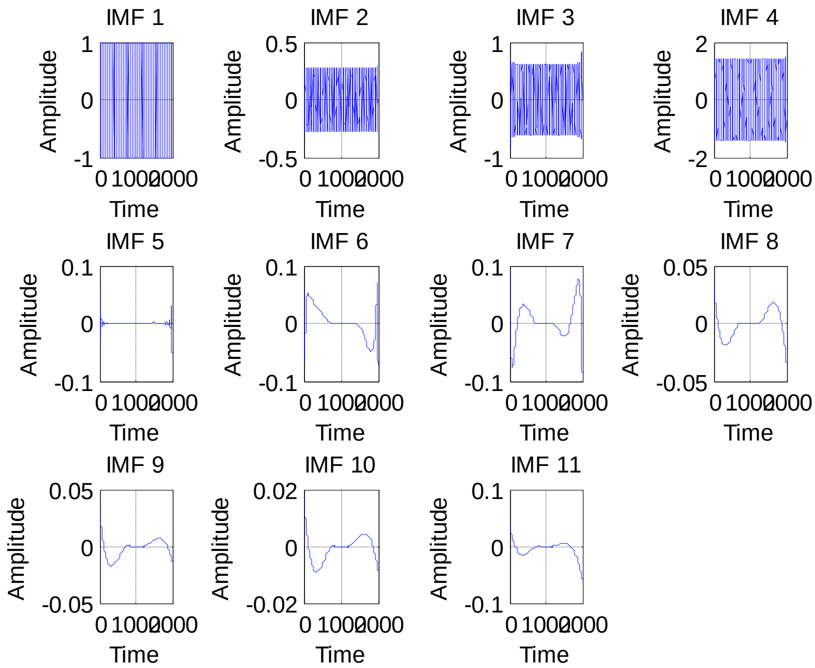

Fig 5: IMF Plot

In this Figure 5 IMF plot has been generated according with different amplitudes. From first Figure 5 it time period -1 to 1 amplitude, can be noted that the signal cannot be predicted according. When Figure 5 is zoomed the signal can be seen as digital and with negative and positive amplitude.

IV. CONCLUSION

This research aimed to examine the viability of EMD as an audio and speech analytics tool (Huang transform). The dissertation's key contributions include audio coding, audio watermarking, and denotation speech for copyright protection. The obtained results in the analysis of square wave indicate the true potential of EMD as (adaptive) analytical tool, even in contrast to the well-established methodologies such as the Wavelets approach, the MMSE filter, AAC and MP3 codecs.

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