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Research Article

FEATURE EXTRACTION OF SIGNALS USING EMPIRICAL MODE DECOMPOSITION

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ABSTRACT

This paper presenting a novel method, a non-linear Technique called as Empirical mode decomposition. EMD is an adaptive method for non-stationary signals to represent them as sums of zero-mean amplitude and frequency. It decomposes the signal into several mono-component signals called intrinsic mode function (IMF). The Hilbert transform is used here to analyse this zero mean component to get instantaneous frequency & amplitude variation. EMD clearly identifies non-stationary events consisted in signal. It also used to analyse the solar radiation real world signals, by identifying natural modes of oscillations in it. With additional advantage of EMD method, it is defined for cloud classification by event detection and observing solar radiation on cloud event.

INTRODUCTION

Nowadays, we have seen that in real world of technology there exist abundant kinds of signal which carry a lot of information. Signal is defined as any physical quantity that varies with time, space. In the field of Signal processing, technicaly the classification of signal is extremely important. There are various types of signals ranging from simple structures to complex ones. Thus, diverse techniques have been developed to analyze, interpret, manipulate and process those signals. There are several categories of signals such as stationary or non-stationary. Signals that are constant in their statistical parameters such as mean and variance over time are stationary and if signals statistics are varied with time, the signal is defined as non-stationary. Each kind of signal has its own feature and this feature extraction involves simplifying the amount of resources required to accurately describe a large set of data.If extracted features are distinct enough; even a simple classifier can accurately and efficiently classify the data. Specific features may contain periodic elements, trends, non-stationary events, and for analyzing that many methods have been developed such as Fourier analysis, short time Fourier analysis, wavelet analysis. This method fails for non-stationary events and detecting trends in signal.

Hence, Empirical mode decomposition (EMD) method has proposed by N. E. Huang et al in 1998 for analyzing non stationary, nonlinear signal. In this iterative method of finding intrinsic mode functions (IMF) from a non-stationary signal by sifting procedure is explained. The Sifting procedure is nothing but removal of lowest frequency from a signal until highest frequency remains in the signal and this is termed as IMF. These IMFs could be easily analyzed for their instantaneous frequencies and bandwidths by simple application of Hilbert transform on these IMFs. After removal of first IMF same procedure is repeated until residue becomes monotonic signal i.e. lowest frequency signal.

Z. Wang, K. Sassen has presented an improved cloud classification algorithm using active and passive remote sensing at the southern great plains cloud and radiation test bed site. Cloud classification has done using vertical and horizontal cloud properties, the presence, or absence of precipitation, liquid water path, and downward IR brightness temperature. Main improvements made by including cloud phase determination.

Solar radiation on earth is intermittent in nature. Intermittency is due to the variation of irradiance with the cycle of day, weaker radiation and shorter days during winter, and general variability such as presence of clouds. The brightness of the Sun varies on all time scales, and there is increasing evidence that this has an influence on climate. Solar radiation variations are non-stationary in nature and dependent on cloud coverage and geographical indices.

Cloud classification products not only supports cloud studies which need to group clouds according to cloud types, but also

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provides necessary information for radiation variability assessment. Classifying clouds into different categories is an important task for cloud remote sensing and global cloud climatology studies. Algorithms based on different cloud spectral, textural, and physical features from satellite passive sensors have been developed for cloud classification. However, ground based remote sensing loud studies are necessary for local climate changes and variability assessment. Algorithms to classify cloud type using this approach are necessary. Variations in solar radiation are mainly due to clouds. Thus we can classify the clouds by observing and analyzing the variability in solar radiation.

The EMD method described here proved useful in a variety of applications such as diverse as climate variability, biomedical engineering, etc.

METHODOLOGY

A signal which has changing amplitude and frequency with respect to time is a Non-stationary signal. To represent this non-stationary signals as a combination of various sinusoidal signal will not be accurate and single frequency cannot defined. Now, it is necessary to a flexible process to detect the frequency change with time. This gives rise to an idea of Instantaneous frequency (IF). The EMD method is Empirical because the local characteristic time scales of the data itself are used to decompose the timeseries. Previously, Fourier analysis or wavelet transform is used as a general tool for examining timeseries. There are some crucial restrictions of Fourier analysis: the system must be linear and the data must be periodic or stationary. Wavelet transform decomposes the signal into family of scaled and translated functions.

Here, shown in fig 1 the EMD process, it is an iterative procedure for separating oscillations by simple sifting process.

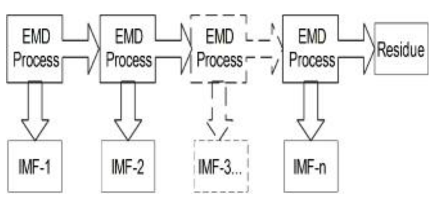

Fig1 EMD process

The method extracts mono component and symmentric components from non-linear & non-stationary signals. Sifting indicates removing of lowest frequency information until only the highest frequency remains. The decomposed signals are intrinsic mode function, is a zero mean osillatory waveform, possibly modulated in both amplitude and frequency. They satisfy the following two conditions:

1) For a data set, the number of extreme and zero crossings must either be equal or differ at most by one.
2) At any point, the mean value of the envelope defined by the local maxima and local minima is zero.

Computational algorithm to find IMF

The hung et. al. algorithm for extracting an IMF by sifting process is as given below:

Step1: The upper and the lower envelopes are constructed by connecting all the maxima and all the minima of signal x (t) with cubic splines, respectively.

Step 2: Take the mean of the two envelopes and let it be defined

$$\text{as } m(t) = \frac{x_{max}(t) + x_{min}(t)}{2}$$

Subtract the mean m (t) from the original signal $x(t)$ to get a component $h_1(t)$ where $h_1(t) = x(t) - m(t)$

These steps has shown in Fig 2 in it envelops of maxima minima are given.

Step 3: If $h_1(t)$ satisfies the two conditions of IMF, given above then $h_1(t)$ is the first IMF else it is treated as the original function and steps 1-3 repeated to get component $h_{11}(t)$such that : $h_{11}(t)=h_1(t)-m_1(t)$

Step 4: The above sifting process is repeated k times and h_1 k (t) become first IMF known as IMF1, it is stored in $C_1(t)$ Separate IMF 1 from $x(t)$ and let it be $r_1(t)$, such that $r_1(t) = x(t) - h_1k(t)$ after nine iterations the First IMF, IMF-1 found

Step 5: Now taking the signal $r_1(t)$ as the original signal and repeating the steps 1-4 second IMF is obtained.The above procedure is repeated for n times and such n IMFs are obtained. When $r_1(t)$ becomes monotonic function no further IMF can be extracted.

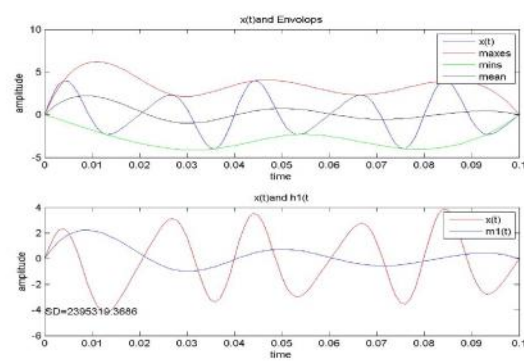

Fig 2 Data upper and lower envelope defined by local extreme & means value of two envelopes

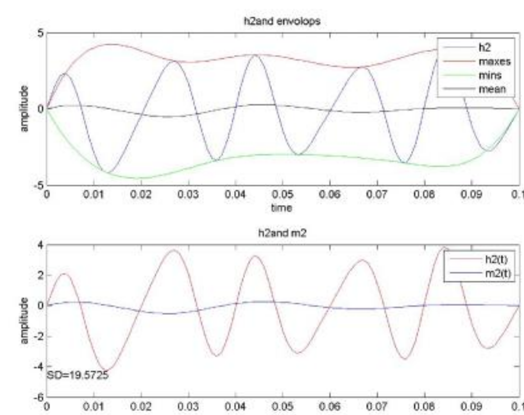

Fig 3 data and mean of signal for iteration 2

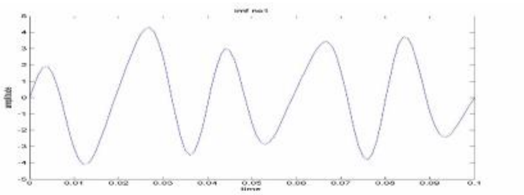

Fig 4 IMF First (IMF 1)

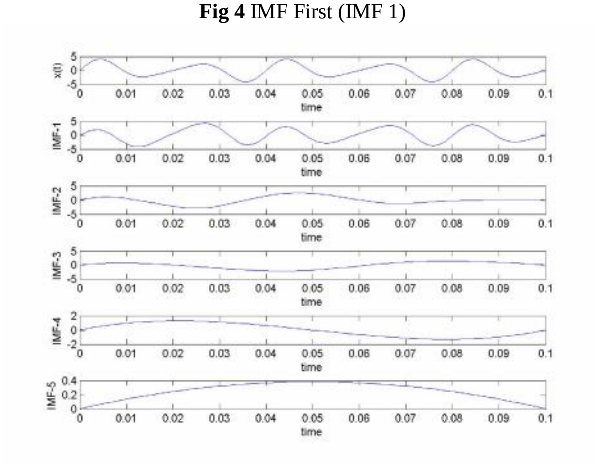

Fig 5 IMFs obtained by sifting process on sample signal

At the end we have residue *r(t)*and collection of IMFs C_1 *to* $C_n(t)$ such that

$$x(t)=\sum_{i=1}^{n} C_i(t)+ r_i(t)$$

Hilbert Transform

Generally, any non-linear distorted waveform can be regarded as harmonic distortions. Harmonic distortions are a mathematic artificial consequence of imposing a linear structure on a non-linear system. They may not have mathematical meanings but physical meanings. Hence the physically meaningful way to describe a non-linear system is instantaneous frequency, which will reveal the intrawave frequency modulations. The Hilbert transform relates real and imaginary parts of a complex function on real line. In this Hilbert transform has been used to find real and imaginary part of signal *x*(*t*) which further used for calculating instantaneous phase and frequency of signal.

Hilbert Haung spectral analysis

Hilbert spectrum shows instantaneous frequencies consisted in each IMF separately with respect to time. Hilbert spectrum of test signal is shown in Fig 6.The instantaneous frequency can be considered as average of all the frequencies that exist at a given moment, while the instantaneous bandwidth can be considered as the deviation from that average. This obtained instantaneous amplitude, frequency used for classification and selecting features of signal by analyzing statistical properties of IMFs.

Analysis of Solar Radiation data

The brightness of the Sun varies on all timescales, and there is an increasing influence on climate. Solar radiation variations are non-stationary in nature and dependent on cloud coverage and geographical indices.

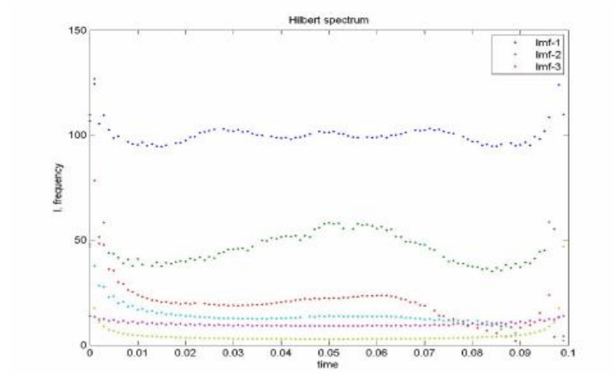

Fig 6 Hilbert transform of the test signal

This leads to analyse the variability in solar radiation.Classifying clouds into different categories is an important task for cloud remote sensing and global cloud climatology studies. Algorithms based on different cloud spectral, textural, and physical features from satellite passive sensors have been developed for cloud classification.However, ground based remote sensing cloud studies are necessary for local climate changes and variability assessment. The solar radiation data has been taken from renewable energy laboratory at Government College of Engineering, Aurangabad (M.S.) India. Figure 7 shows the solar radiation data used for analysis. Many methods have been developed for data analysis but these fails for climate data because of non linearity and non stationarity of data. A new analysis method, the Hilbert-Huang transform which is designed for non-linear and non-stationary data has used to investigate natural modes of oscillation in solar radiation. Data with different weather conditions was selected for analysis. On analyzing with EMD it has been found that 29 IMFs were found for this period. These are shown in Figure 8

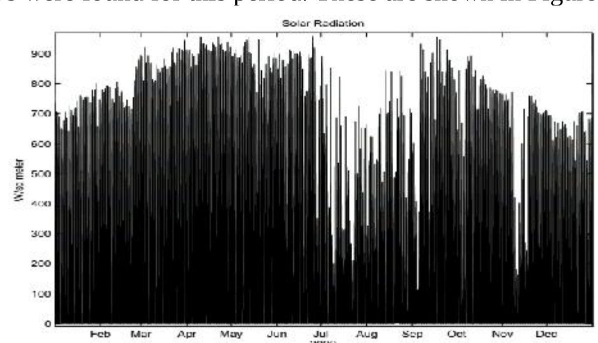

Fig 7 Solar Radiation Data

Cloud Classification

As seen in above section, the solar radiation can be summarized with EMD and with respect to that as shown Fig 9 the cloud classifications has beeen seen according to National Weather Service Louisville, KY. Clouds are classified according to cloud top pressure, cloud optical depth, their height above and appearance (texture) from the ground. The following cloudroots and translations summarize the components of cloud classification system.

1. Cirro-: curl of hair, high.
2. Alto-: mid.

3. Strato-: layer.
4. Nimbo-: rain, precipitation.
5. Cumulo-: heap

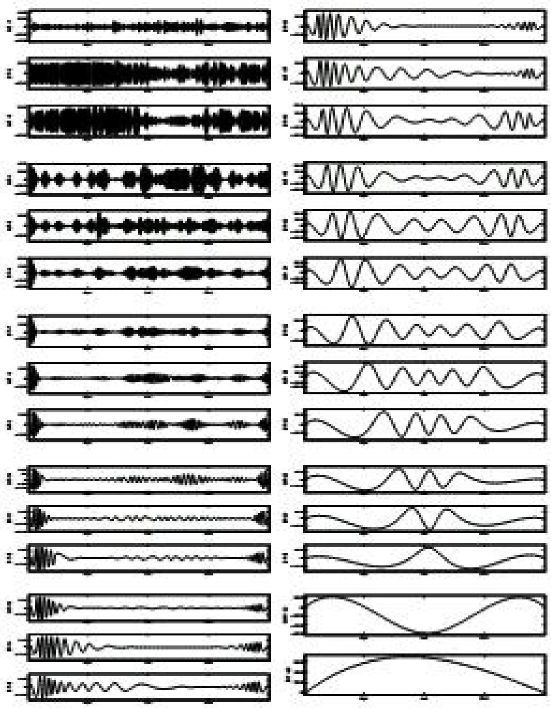

Fig 8 IMFs obtained from Solar Radiation

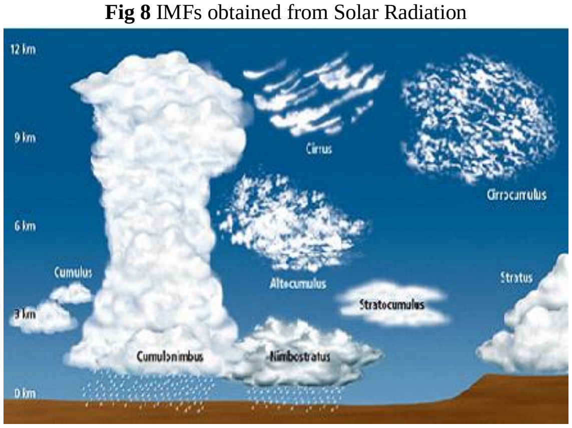

Fig 9 The various types of clouds (picture taken from

http://www.crh.noaa.gov/lmk/?n=cloud classification) Residue will help us to classify major group of cloud type

while IMFs helpto detect cloud layer type. If two IMFs are present, it means that there will be single layer of cloud. Likewise if there are three IMFs, means two layers of cloud are present in the sky.Standard deviation in instantaneous amplitude of IMF-1, IMF2 correlates directly with optical depth of cloud.

STD in Amplitude Of residue	Cloud type	Height of cloud
≤ 50	Nimbo- stratus	0-3 Km
50-150	Cumulo nimbus and/or cumulus	0-6 Km
150-250	Cumulus and/ or strato-cumulus	3-6 Km
250 ≥	Clear day, Cirrus, Cirro-cumulus	9-12 Km

CONCLUSION

The Empirical Mode Decomposition and Hilbert spectral analysis, comprising the Hilbert Huang transform, can be applied with great success for nonlinear and non-stationary signal analysis in various areas.

- Natural modes of oscillation has separated, cycle of day and time of day has identified using EMD on solar radiation data.
- The different layers of clouds are classified using empirical mode decomposition according to standard deviation in amplitude of IMFs.
- The observed classification will be helpful for finding local solar radiation variability assessment. Analyzed data also gives instantaneous frequencies which can be used for obtaining speeds of drifting clouds and their time periods can be obtained from instantaneous frequencies.
- It can be used as faster algorithm for cloud classification and event detection as it is completely one dimensional data driven approach. The given classification and analyzed results will be helpful for predicting weather conditions.

References

1. N. E. Hung, *et al.*, “The Empirical Mode Decomposition and the Hilbert Spectrum for Nonlinear and Non-Stationary Time Series Analysis”, Proceedings of Royal Society A Mathematical Physical and Engineering Sciences 454 (1998) pp. 903-995.
2. K. Sassen, Z. Wang,“ An Improved Cloud Classification Algorithm Based on the SGP CART Site Observations”, 14*th* ARM Science Team Meeting Proceedings, Albuquerque, New Mexico, March-2004, pp. 1-11.
3. Stuti Shukla, S. Mishra and Bhim Singh, “Empirical-Mode Decomposition With Hilbert Transform for Power-Quality Assessment”, IEEE Transactions on Power Delivery, Vol. 24, No. 4, October 2009 pp. 2159-2165.
4. “Cloud types for Observers”[Online]. Available: http://www.metoffice.gov.uk/ media/pdf/r/i/Cloud_types_for_observers.p
5. Nastaran Rahnama, “Empirical Mode Decomposition and Analysis of Non-Stationary Cardiac Signals”, Thesis Presented to Department of Electrical and Computer Engineering, Ryerson University Toronto, Ontario, Canada,August-2013,pp.1–93.
6. G. Rilling and P. Flandrin, “One or Two Frequencies? The Empirical Mode Decomposition Answer”, IEEE Transactions on Signal Processing, Vol. 56, January-2008 85–95.